

**THE UNITED STATES ARMY
MEDICAL DEPARTMENT**

JOURNAL

April-September 2016



**AMEDD AT WAR:
LESSONS LEARNED
2001-2015**



**THE UNITED STATES ARMY
MEDICAL DEPARTMENT**

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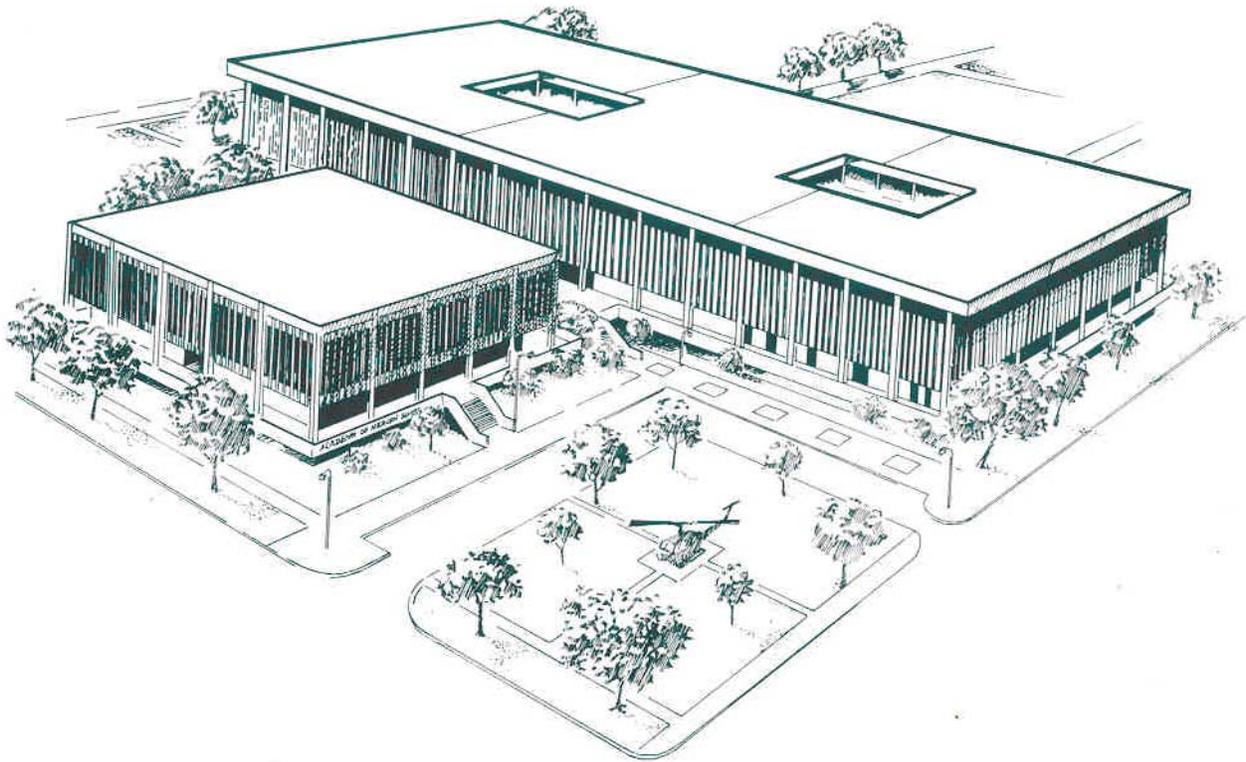
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ARMY MEDICINE
Serving To Heal...Honored To Serve



The US Army Health Readiness Center of Excellence
The Army Medical Department Center and School
ENVISION, DESIGN, TRAIN, EDUCATE, INSPIRE
Joint Base San Antonio Fort Sam Houston, Texas

Army Medical Department at War: Lessons Learned

COL Clinton K. Murray, MC, USA
MAJ Scott R. Hitter, SP, USA
MG Stephen L. Jones, MC, USA

On July 27, 1775, the Continental Congress established a hospital for an Army of 20,000 and appointed the following officers and attendants: one director general and chief physician, 4 surgeons, one apothecary, 20 surgeon's mates, one clerk, 2 storekeepers and one nurse for every 10 patients. This marks the organization of the Army Medical Department (AMEDD).

The following 240 years included many significant contributions to the nation and the field of medicine. When the AMEDD immunized the Army against smallpox during the Revolutionary War, the AMEDD proved that mass immunization was effective, and subsequent global campaigns eradicated the disease. The history of AMEDD is replete with distinguished figures who have contributed greatly to the field of medicine. MAJ William Beaumont, a Medical Corps officer, is not only the father of gastroenterology but also of the discipline of physiology. MAJ John Shaw Billings established The Surgeon General's Library, which is now The National Library of Medicine. MAJ Walter Reed demonstrated that the mosquito was the vector of transmission for yellow fever. COL William Gorgas, who led the campaign against mosquitos in Panama, made the construction of the Panama Canal possible by controlling the outbreaks of yellow fever and malaria that threatened its completion.

Among the many advances achieved in the last century, a number of which are shown in the Table, the AMEDD has produced major advances in trauma management, blood transfusions, and the treatment of shock. During the Korean War, the AMEDD developed innovative techniques used for renal dialysis; and during the Vietnam War, it made significant improvements in the treatment of acute respiratory failure. Throughout its illustrious history, AMEDD continues to progress and evolve by learning from each war and applying that knowledge in future conflicts. The lessons we learned in the trenches of the 2 World Wars, the frontlines of Korea, and the rice paddies of Vietnam made AMEDD stronger in the towns of Somalia, the deserts of Iraq, and the mountains of Afghanistan. The lessons we have learned in the most recent conflicts in the Middle East will make us stronger,

and more effective in the conflicts to come. The knowledge gained from conflicts in the past has been applied in many ways. We have developed the Combat Lifesaver and 68 W Programs, Tactical Combat Casualty Care, damage control resuscitation, and damage control surgery. Through the years, the AMEDD has also developed new treatments and rehabilitation methods in all disciplines of medicine that have allowed Soldiers and Families to lead productive lives.

During the past 14 years of war, the AMEDD helped raise casualty survival rates from 76% in Vietnam to over 92% during the wars in Iraq and Afghanistan.³ That means that over 8,000 casualties who would have died in previous conflicts returned home to their families. Our Warfighters fight more effectively knowing that AMEDD is on the battlefield to care for them if injured, and they take comfort in knowing that AMEDD is caring for their Families back home.

The quality of medical care markedly advanced during the wars in Iraq and Afghanistan due to evidence-based medicine.⁴⁻⁶ In addition, the advances in body armor, fire retardant clothing and vehicles, vehicle survivability, evacuation assets, and communication prominently enhanced patient outcomes. Finally, since 80% of initial care is done by the patient himself or buddy aid, trauma medical management training of entire units—especially nonmedical personnel—can significantly impact overall morbidity and mortality.⁷

Substantial efforts to codify and document care have proved that significant improvement has occurred over the last 14 years. Despite the statutory prohibition on the performance of randomized controlled trials in the combat zone (10 USC 980, Limitations on Use of Humans as Experimental Subjects), many lessons have still been learned, rapidly disseminated, and effectively applied. Initially, the Advanced Technology Applications to Combat Casualty Care annual meeting allowed sharing of trauma-related lessons. The meeting transitioned to the Military Healthcare System Research Symposium to broaden the lessons learned across all military healthcare issues. Peer-reviewed journal supplements

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<p>AMEDD Advances in Combat Casualty Care.*</p>
<p>World War I</p> <ul style="list-style-type: none"> Use of intravenous fluids and blood transfusions Motorized ambulances Laparotomy for penetrating abdominal wounds Use of surgical specialists Effective topical antisepsis: Carrel-Dakins wound irrigation system Antitetanus serum Radiologic localization of foreign bodies Neurosurgical trauma databank Characterized the bacteria and infection rates associated with wounds
<p>World War II</p> <ul style="list-style-type: none"> General availability of whole blood and plasma Formulaic resuscitation of burn patients Availability of “well trained” surgeons and use of specialty specific Auxiliary Surgical Groups Hierarchical organization of trauma care Use of antibiotics Use of fixed wing aeromedical evacuation Identification of “Wet Lung in War Casualties”
<p>Korean War</p> <ul style="list-style-type: none"> Fluid resuscitation adequate to correct shock and prevent organ failure Availability of board certified surgical specialists Forward availability of definitive surgery Use of helicopters for patient transport Primary repair and vascular grafts for injured vessels Use of hemodialysis in theater of operations Identification of high output renal failure Recognition of seasonal variation in bacteria recovered from battle wounds
<p>Vietnam War</p> <ul style="list-style-type: none"> General use of helicopters for patient transport Monitoring of organ function in theater of operations Blood gas measurements <ul style="list-style-type: none"> Serum chemistries Portable radiology equipment Use of mechanical ventilators in theater of operations Effective topical antimicrobial chemotherapy for burns Staged intercontinental aeromedical transport of burn patients Identification of Acute Respiratory Distress Syndrome Established Vietnam Vascular Registry
<p>Operation Desert Storm/Shield</p> <ul style="list-style-type: none"> Burn team augmentation of evacuation hospitals to provide theater-wide burn care Reactivation of intercontinental burn patient transport system
<p>Operations in Iraq and Afghanistan</p> <ul style="list-style-type: none"> Development of a military trauma registry “Low volume” resuscitation fluids – colloids and red blood cells Hemostatic agents <ul style="list-style-type: none"> Systemic Topical Use of “damage control” initial surgery Use of endovascular stents Common use of external fixators Improved tourniquets CAD/CAM limb prostheses Pain control Concussion care Established clinical practice guidelines for combat casualty care Identification of coagulopathy in injury Challenges of treating infections with fungus and multidrug-resistant bacteria Deployed Electronic Health Record Reach back capability with telehealth and programmatic email communication
<p>*Data from Pruitt,¹ Pruitt et al.²</p>

and Borden Institute textbooks (<http://www.cs.amedd.army.mil/borden/>) have been published for wide dissemination of the information. In addition, guidelines have been developed through collaborative military and civilian subject matter expertise with regular revisions as new lessons are learned.⁸⁻¹²

A 3-day meeting was held September 9-11, 2015, in San Antonio, TX, to address key lessons across all of the AMEDD Corps that had not been consistently captured in previous publications. Forty-seven lectures* were delivered with a focus on Setting the Stage; Equipment and Techniques; Tactics and Procedures Changes that Impacted Care and Outcomes; Personnel Changes that Impacted Care and Outcomes; Wounded Warrior Care; Programmatic Implementations to Improve Health; Operational System Challenges; Veterinary Care; Public Health Challenges; and Doctrine and Training Programs. Thirty-six lectures were developed into manuscripts that are presented in this issue of the *AMEDD Journal*. These articles highlight key aspects of the lessons learned and address aspects of Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities, and Policy to ensure the lessons are incorporated throughout the Army and Army Medicine.

REFERENCES

1. Pruitt BA. The symbiosis of combat casualty care and civilian trauma care: 1914-2007. *J Trauma and Acute Care Surg.* 2008;64:S4-S8.
2. Pruitt BA, Rasmussen TE, Gueller G. The formula for success in military medical research. *J Trauma and Acute Care Surg.* 2015;79:S64-S69.
3. Eastridge BJ, Mabry RL, Seguin P, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. *J Trauma and Acute Care Surg.* 2012;73:S431-S437.
4. Blyth DM, Yun HC, Tribble DR, Murray CK. Lessons of war: combat-related injury infections during the Vietnam War and Operation Iraqi and Enduring Freedom. *J Trauma and Acute Care Surg.* 2015;79:S227-S235.
5. Murray CK, Hinkle MK, Yun HC. History of infections associated with combat-related injuries. *J Trauma and Acute Care Surg.* 2008;64:S221-S231.
6. Kotwal RS, Howard JT, Orman JA, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg.* 2016;151(1):15-24.
7. Kotwal RS, Montgomery HR, Kotwal BM, et al. Eliminating preventable death on the battlefield. *Arch Surg.* 2011;146:1350-1358.
8. Tactical Combat Casualty Care Guidelines for Medical Personnel. Fort Sam Houston, Texas: US Army Institute of Surgical Research; June 2015. Available at: http://www.usaisr.amedd.army.mil/pdfs/TCCC_Guidelines_for_Medical_Personnel_150603.pdf. Accessed December 4, 2015.
9. TCCC-MP Guidelines and Curriculum [internet]. National Association of Emergency Medical Technicians; 2016. Available at: http://www.naemt.org/education/TCCC/guidelines_curriculum. Accessed December 4, 2015.
10. JTS Clinical Guidelines [internet]. Fort Sam Houston, Texas: US Army Institute of Surgical Research; 2015. Available at: <http://www.usaisr.amedd.army.mil/cpgs.html>. Accessed December 4, 2015.
11. Murray CK, Hospenthal DR. Prevention and management of combat-related infections clinical practice guidelines consensus conference: overview. *J Trauma.* 2008;64:S207-S208.
12. Hospenthal DR, Murray CK. Preface: Guidelines for the prevention of infections associated with combat-related injuries: 2011 update. *J Trauma.* 2011;71(2 suppl 2):S197-S201.

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*Available at <https://www.milsuite.mil/book/groups/ameddcs-hrcoe-lessons-lessoned-conference-2015/overview>

SETTING THE STAGE

Planning for Organizational Success: *Hope is Not a Method*

MG (Ret) David Rubenstein, MS, USA

ABSTRACT

The foundational requirement for US Army Medical Department (AMEDD) organizational success on the battlefield is proper planning in accordance with Army doctrinal and tactical guidance. The same can be said for every type of AMEDD garrison-based organization. Commanders and leaders of AMEDD garrison-based organizations must be familiar with and rehearsed in the military decision making process, and use it to their advantage in support of the Warfighter and his or her family.

Hope is Not a Method

Gordon R. Sullivan and Michael V. Harper¹

THE PERSPECTIVE

Admiral Sergei Gorshkov of the former USSR knew the American military well when he said “the most difficult thing about planning against the Americans is that they do not read their own doctrine, and they would feel no particular obligation to follow it if they did.”² An anonymous American Soldier unknowingly supported the Admiral’s observation with the comment “as a former Soldier, let me assure you, ain’t none of us ever read those damn things. Field manuals just take up space in some back office and go untouched for years before someone throws them out.”³

THEY SEE US AS DIFFERENT

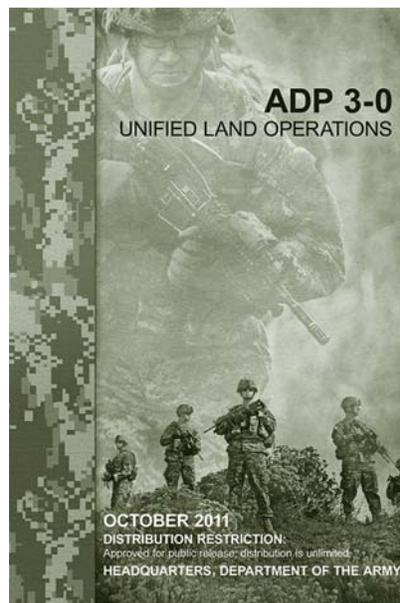
A nonhealthcare Army colleague once expressed to me his sympathy for the plight of the military healthcare leader. “You healthcare leaders,” he said “work by committee, always want to talk, are constrained by guilds, feel a need to reach consensus, try to influence others instead of giving orders, and lead people who want to govern themselves.” His conclusion: “I don’t envy you one bit.”

In this article, I do not argue the point that leadership skills are both similar and different across a range of specialties within the Army and the military. We must, though, understand that some of our colleagues see us military

healthcare leaders, and our organizations, as dramatically different from them and their organizations. Unfortunately, this opinion can put our work and our organizations at a disadvantage when trying to get approval of or simple synchronization to operational plans.

BUT WE ARE THE SAME

The Army’s foundational doctrinal publication, *Army Doctrine Publication 3-0 (ADP 3-0)*,⁴ defines “Army doctrine [as] a body of thought on how Army forces operate as an integral part of a joint force.”^{4(p1)} This capstone doctrine establishes “the Army’s view of the nature of operations, the fundamentals by which Army forces conduct operations, and the methods by which commanders exercise mission command.”^{4(p1)}



The family tree for *ADP 3-0* goes back to 1923 and the Army’s publication of its *Field Service Regulations*. This publication was “designed especially for the government of the operations of large units and of small units forming a part of larger units.”⁵ In it, the Army outlines the underlying doctrine to guide the decisions and actions of commanders and staffs in land operations. Sanitation, hospitalization and evacuation have a prominent place in *Field Service Regulations*: Chapter X (Shelter) of Part I (Operations) and Chapter II (Hospitalization and Evacuation) of Part II (Administration).

The 1923 *Field Service Regulations* served as the precursor to *Field*

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Manual 100-5, Field Service Regulations, Operations, published in 1941 to disseminate Army doctrine broadly across an Army rapidly expanding for future operations, which were realized as World War II. In the Preface of the 1992 reprint by the US Army Command and General Staff College, historian Christopher Gabel points out that “The 1941 version of *FM 100-5* has long been recognized as a classic piece of doctrine writing, remarkable for its clarity of concept and prose.”⁶ However, unlike its predecessor, health services were not addressed in that publication.

Through the intervening years, *Field Manual 100-5* was continuously updated based on contemporary thinking developed from lessons of past and current efforts and expectations of future efforts. The current state of that evolution is now vested in *ADP 3-0* which, in addition to presenting the Army’s capstone doctrine, “serves as the basis for decisions about [Army] organization, training, leader development, materiel, Soldiers, and facilities.”^{4(p1)}

Nowhere in the various editions of publications defining Army operations do we see that capstone doctrine as intentionally limited to field units or warfighting operations. In fact, “operational art is not associated with a specific echelon or formation, nor is it exclusive to theater and joint force commanders. Instead, it applies to any formation that must effectively arrange multiple, tactical actions in time, space, and purpose to achieve a strategic objective, in whole or in part.”^{4(p9)} Garrison-based Army Medical Department units and organizations certainly operate in “multiple, tactical actions in time, space, and purpose to achieve a strategic objective....”^{4(p9)}

As the discussion of *ADP 3-0* above demonstrates, knowledge and application of Army doctrine applies to all Army organizations, those in the field operating at the tip of the spear, those in field and garrison locations planning the operations, and those uniquely in garrison locations supporting the fight and the Warfighter. Whether Soldiers in combat arms, combat support, and combat service support, all are held to the same philosophy, thinking, and expectations when it comes to Army operations within our construct called Army doctrine.

DOCTRINE AS IT APPLIES TO PLANNING

In *ADP 3-0*, Army capstone doctrine defines an operations process as “a commander-centric activity, informed by the mission command approach to planning, preparing, executing, and assessing military operations.”^{4(p10)} From that foundation, *ADP 3-0* tells us “planning is the art and science of understanding a situation, envisioning

a desired future, and laying out effective ways of bringing about that future.”^{4(p10)} To understand, envision, and develop solutions to unfamiliar problems requires that “leaders integrate this methodology with the detailed planning typically associated with the military decisionmaking process to produce executable plans.”^{4(p10)}

The concept of mission command is not unique to the combat arms commander, leader, or organization. Nor does it intend to exclude the medical commander, leader, or organization. From our own Army doctrine we learn “the medical commander exercises mission command (authority and direction) over his subordinate medical resources. As discussed in Army doctrine on unified land operations, “the commander is the focus of mission command....”⁷

Army health system support doctrine to the warfighter and tactical units is outlined in *Army Techniques Publication 4-02.3 (ATP 4-02.3)*.⁸ While the primary focus for *ATP 4-02.3* is for “Army Health System (AHS) support to maneuver forces,” it specifically applies to [author’s emphasis] “all commanders and their staffs, command surgeons, AHS planners, and Army Medical Department (AMEDD) personnel and units.”^{8(pvi)} The reasoning for this emphasis is unambiguous: in its ultimate design, all AMEDD support is to the commander and Warfighter in the field. Within the AMEDD, garrison-based leaders, staffs, and organizations are as important as colleagues in tactical field-based healthcare organizations in accomplishing the AMEDD responsibility “to effectively execute AHS operations to support the tactical commander [requires] comprehensive planning....”^{8(p3-1)}

That comprehensive planning, to ensure the tip of the spear is well supported by both AMEDD tactical units and AMEDD garrison-based units, requires AHS planning on par with those being supported. To that end, commanders and units being supported by the AMEDD use the military decisionmaking process to develop comprehensive plans. It stands to reason, then, that AMEDD garrison-based organizations should also use the military decisionmaking process.

The linkage is clear. Army doctrine applies to all Army organizations; Army operations come from mission command focused planning; Army operational planning is a result of the military decisionmaking process; tactical and garrison-based AMEDD organizations are a part of the Army; and the AMEDD commander, like his nonhealthcare peers, exercises mission command. It stands to reason, therefore, that AMEDD operational planning in both field and garrison-based organizations

should be based on the military decisionmaking process (MDMP).

THE MILITARY DECISIONMAKING PROCESS

Field Manual 6-0 “applies to the Active Army, the Army National Guard/Army National Guard of the United States, and the United States Army Reserve unless otherwise stated.”^{9(pvi)} It presents the military decisionmaking process, one of the Army’s 3 planning methodologies.^{9(p9-1)} Key to this article, the manual makes no exclusion for garrison-based AMEDD units. It provides guidance for planning across all components and branches of the Army.



To that end of inclusivity, “Effectively conducting the military decisionmaking process requires leaders who understand the fundamentals of planning.”^{9(p9-1)} Operational planning in support of the commander and Warfighter is not an activity for amateurs. Nor is it an activity for a small subsection of the staff with knowledge of the characteristics, steps, and plans. Instead, the “process helps commanders, staffs, and others think critically and creatively while planning.”^{9(p9-1)}

Also, to be involved in the process means one understands the process. The MDMP is taught to officers and noncommissioned officers alike during professional military education. The depth and complexity of that exposure varies depending on the curriculum of the specific course. Further, continuing practice with the elements of the MDMP is dependent on the expectation of the commander and senior leaders. In fact, “the commander is the most important participant in the MDMP. More than simply decisionmakers in this process, commanders use their experience, knowledge, and judgment to guide staff planning efforts.”^{9(p9-2)}

THE CHALLENGE OF DOCTRINE, ORGANIZATION, TRAINING, MATERIAL, LEADERSHIP, PERSONNEL, FACILITIES

This returns us full circle to the opening paragraph of this article and the realization that many of our colleagues, rightly or wrongly, see colleague leaders in garrison-based AMEDD organizations as being different. Unless those in garrison-based organizations learn, understand, practice, and use Army doctrine related to operations planning, they will be outsiders and, as outsiders, minimized. Garrison operations to support the warfight and the Warfighter are not business as usual,

just at a bigger scale or faster rate. Garrison operations to support the warfight and the Warfighter are different than day-to-day health-care operations. The population is unique, their needs are unique, the universe of interested people is unique, and the intense scrutiny given to the process is unique.

As a result, these unique garrison operations by AMEDD organizations in support of the warfight and the Warfighter require planning. Published Army doctrine describing effective planning requires use of the MDMP. Implementing MDMP requires commanders, leaders, and staff who are schooled and comfortable with it. Schooling comes from attending professional military education; comfort comes from routine use of the process.

There are at least 4 results that accrue from knowing, practicing, and using the MDMP, three of which are: plans that our line colleagues understand; plans that can be easily integrated with those plans developed by other Army and military organizations; and plans that lead to successful mission command and successful missions. The fourth result can best be voiced in the negative: MDMP-developed plans ensure that commanders, leaders, and staffs do not rely on hope as a method to a successful outcome. *Hope is Not a Method.*¹

From the perspective of Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities (DOTMLPF), what is the commander, the staff leader, the AMEDD to do? The answer to the doctrine, training, and leadership elements of the DOTMLPF challenge is 2-fold: schooling and use. First, the MDMP must be schooled at all AMEDD professional military education. Then, the MDMP must be inculcated into the planning DNA of all AMEDD organizations and their people. Its schooling and its use are not limited to field-based, tactical units alone. Commanders and leaders of AMEDD garrison-based organizations must be familiar with and rehearsed in the military decision making process and use it to their advantage in support of the Warfighter and his or her family.

REFERENCES

1. Sullivan GR, Harper MV. *Hope Is Not a Method*. New York, NY: Times Books; 1996.

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2. Military Quotes Mohandas K. Gandhi – Herman Göring [internet]. Available at: <http://www.military-quotes.com/database/g.htm>. Accessed September 1, 2015.
3. askReddit [internet]. Available at: https://www.reddit.com/r/AskReddit/comments/12z7hs/has_anyone_here_ever_been_a_soldier_fighting/c6zk7mg. Accessed September 1, 2015.
4. *Army Doctrine Publication 3-0: Unified Land Operations*. Washington, DC: US Department of the Army; 2011. Available at: http://www.army.mil/e2/rv5_downloads/info/references/ADP_3-0_ULO_Oct_2011_APD.pdf. Accessed January 26, 2016.
5. *Field Service Regulations* [obsolete]. Washington, DC: War Department; 1923:iii.
6. *Field Manual 100-5, Field Service Regulations, Operations* [obsolete]. Washington, DC: War Department; 1941:i. Available at: <http://ibiblio.org/hyperwar/USA/ref/FM/FM100-5/index.html>. Accessed January 26, 2016.
7. *Field Manual 4-02: Army Health System*. Washington, DC: US Department of the Army; 2013:2-30. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm4_02.pdf. Accessed January 26, 2016.
8. *Army Techniques Publication 4-02.3. Army Health System Support to Maneuver Forces*. Washington, DC: US Department of the Army; 2014. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/atp4_02x3.pdf. Accessed January 26, 2016.
9. *Field Manual 6-0: Commander and Staff Organization and Operations*. Washington, DC: US Department of the Army; 2014. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm6_0.pdf. Accessed January 26, 2016.

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Data-driven Casualty Estimation and Disease Nonbattle Injury/Battle Injury Rates in Recent Campaigns

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ABSTRACT

To ensure Soldiers are properly equipped and mission capable to perform full spectrum operations, Army medical planners use disease nonbattle injury (DNBI) and battle injury (BI) admission rates in the Total Army Analysis process to support medical deployment and force structure planning for deployed settings. For more than a decade, as the proponent for the DNBI/BI methodology and admission rates, the Statistical Analysis Cell (previously Statistical Analysis Branch, Center for Army Medical Department Strategic Studies) has provided Army medical planners with DNBI/BI rates based upon actual data from recent operations. This article presents the data-driven methodology and casualty estimation rates developed by the Statistical Analysis Cell and accredited for use by 2 Army Surgeon Generals, displays the top 5 principal International Classification of Disease, 9th Revision, Clinical Modification (ICD-9-CM) diagnoses for DNBI/BI in Operation Iraqi Freedom/Operation New Dawn (OIF/OND), and discusses trends in DNBI rates in OIF/OND during the stabilization period. Our methodology uses 95th percentile daily admission rates as a planning factor to ensure that 95% of days in theater are supported by adequate staff and medical equipment. We also present our DNBI/BI estimation methodology for non-Army populations treated at Role 3 US Army medical treatment facilities.

An important task of medical planning involves the inevitable occurrence of disease and nonbattle injury (DNBI) hospitalizations in deployed troops. Historically, DNBI have exceeded combat-related injuries in every major US military operation.¹⁻⁵ In 2002, the Office of The Surgeon General noted that existing projection models based on subject matter expert opinions produced admission rates much higher than those recorded during recent operations and asked the Center for Army Medical Department (AMEDD) Strategic Studies (CASS) to study the DNBI issue.⁶ The Statistical Analysis Cell (previously Statistical Analysis Branch, CASS) was given the task to provide a new methodology for casualty estimation and to calculate DNBI rates for recent operations. Our approach was to develop a data-driven methodology based on deployed population and administrative healthcare data collected in theater and to analyze profiles of DNBI rates over time.

In this article, we briefly describe 2 distinct disease and nonbattle injury/battle injury (DNBI/BI) methodologies, one for deployed US Army Soldiers and one for other groups of patients treated at Role 3 Army military treatment facilities (MTFs) in theater. We present variability in daily DNBI/BI rates over time, show how DNBI/BI rates changed through the campaign, describe

which diagnoses mainly contributed to the volume of incidence rates, and provide recommendations for future analyses.

DEVELOPMENT OF DNBI RATES METHODOLOGY

The study of DNBI admission rates was conducted by merging records from existing military databases, including US Army Soldier deployment data from the Contingency Tracking System files from the Defense Manpower Data Center (DMDC) and hospitalization data from the Standard Inpatient Data Record (SIDR) files acquired from the Army's Patient Administration Systems and Biostatistics Activity (PASBA). The DMDC data identified all Soldiers who were deployed to the various operations by date of arrival in theater and date of departure from theater. Battle injuries were identified through use of NATO Standardization Agreement (STANAG) 2050 trauma indicator "0" (direct result of war) or "1" (other battle injuries) and cause of injury codes 300-479 (injuries caused by enemy action). Note that the SIDR variables for STANAG codes are well-populated and provide a fairly reliable identification for cause of injury.⁷ For the remaining records, we determined disease cases and nonbattle injury cases using the principal diagnosis code. A hospital admission record was identified as disease if the 3-digit

ICD-9-CM* principal diagnosis code was between 001-799 or 960-999. Nonbattle injury included ICD-9-CM codes 800-959.

We identified 2 types of operations: warfighting and peacekeeping.⁷ Statistical Analysis Cell (SAC) analysts performed extensive data mining of deployment data in Operations Desert Shield/Desert Storm (the Persian Gulf War) and Operation Endeavor (peacekeeping in Bosnia and Kosovo). Admission rates were determined by merging the healthcare data records with the US Army Soldier population data. Daily rates were expressed as the number of admissions per 1,000 Soldiers present in theater on that day. Overall rates expressed as the number of admissions per 1,000 Soldier-days were calculated by taking the total number of hospital admissions that occurred within the analyzed period of time divided by the total number of Soldier-days at risk (present in theater) during the time examined. During the peacekeeping operation, rates varied over time seasonally or with geographic location.⁸ Analysis of the Persian Gulf War data indicated that DNBI admission rates vary during the 3 phases of a warfighting operation—build up, ground combat, stabilization—when these phases can be identified.

Additionally, the Statistical Analysis Cell determined that the traditional use of mean or overall DNBI admission rates in previous medical planning processes carried a significant risk of failing to provide sufficient medical resources for approximately half of the deployed days. To counter this problem, we developed an alternate method to using the mean. The SAC examined daily admission rates using percentile analysis and selected the 95th percentile daily DNBI admission rate as a planning factor. The 95th percentile cutoff point identifies the daily admission rate at which 95% of days had hospital admissions at or below this rate. Only 5% of days had admissions above this planning factor. Note that we examined daily diagnosis profiles and found no statistically significant difference between the top 5% of days with the highest admissions and the bottom 95% of days with lower admissions.⁹

Results of the SAC analysis addressing warfighting operations were approved by The Army Surgeon General, LTG James Peake, and Director, Force Management, Army G-37/FM, MG Dennis Hardy in December 2002. The DNBI 95th percentile admission rates were provided by the SAC to the Center for Army Analysis for DNBI modeling and force structure planning in the Total Army Analysis 2011 process (TAA 11). The analysis

*International Classification of Disease, 9th Revision, Clinical Modification

results were published by Wojcik et al.⁹ Throughout this paper we refer to the term 95th percentile daily DNBI/BI admission rate as a DNBI/BI admission rate.

METHODOLOGY FOR EXPANDED ADMISSION ANALYSIS

The Director, Force Management, concurred with the Office of The Surgeon General that the DNBI analysis should be a continuous process culminating in an annual analysis and report to Army leadership.

In response, the Statistical Analysis Cell embarked upon a project to analyze the rates of hospital admission for disease and nonbattle injuries during recent troop deployments and use the analysis to develop data-driven DNBI web applications for medical deployment and force structure planning. The resulting web tool separately addresses peacekeeping (Bosnia, Kosovo) and warfighting operations (Desert Shield/Desert Storm, Operation Enduring Freedom, Operation Iraqi Freedom/Operation New Dawn), and takes into account the geographic location, phase of the operation (if applicable), and the size and composition of the deployed force. Composition variables include Soldier age, gender, unit type, force component, and enlisted/officer status. The SAC further expanded the admission analyses to include disease, nonbattle injury, battle injury, combat stress, and behavioral disorder rates in addition to combined DNBI rates for US Army Soldiers. In 2005, the DNBI rates were accredited by LTG Kevin Kiley for use as a planning tool by the AMEDD and Army medical planners.¹⁰ In 2011, Army planners made the decision to replace DNBI rates based upon Desert Shield/Desert Storm with admission rates estimated from data collected in Operation Iraqi Freedom.

Also in 2011, the Statistical Analysis Cell received a request to provide the Center for Army Analysis a casualty estimation methodology and estimated admission rates for nontraditional populations (patients other than US Army Soldiers) treated at Role 3 Army MTFs in theater. A different methodology was proposed to estimate DNBI/BI rates for these patients. Admission data records include the patient beneficiary category which indicates the basis under which individuals are provided care at MTFs. Using the beneficiary category, the following groups of patients were identified in collaboration with the Center for Army Analysis: other US uniformed services; coalition forces NATO; coalition forces non-NATO; US government agencies and civilians; contract employees; indigenous population; detainees; and others. Since the populations at risk were not available for these patient groups, the traditional method of rate calculation could not be used. Rates for these patients were defined in terms of US Army Soldier population at

risk. The new estimation method was accomplished by calculating ratios of the number of admissions for each group of patients to the number of Soldier admissions at Army Role 3 MTFs during the same period of time. Next, these ratios were multiplied by the 95th percentile Army Soldier daily admission rate during the examined period of time to estimate the rates for nontraditional groups of patients treated at Role 3 Army facilities (expressed per 1,000 Soldiers). Results of this analysis were incorporated into the TAA processes starting with TAA 14-18.

ILLUSTRATION OF DNBI/BI RATE METHODOLOGY

Data and admission rates presented in this paper were obtained using the sources and methods described above. For this illustration, US Army Soldier deployment data and US Army Role 3 hospitalization data were summarized for the entire campaign of Desert Shield/Desert Storm (DS/DS), for Operation Enduring Freedom for the period September 11, 2001, through December 31, 2012, and for Operations Iraqi Freedom and New Dawn (OIF/OND) for the period September 1, 2002 through December 31, 2011. Three distinct phases were identified for OIF/OND: buildup (September 1, 2002, to March 19, 2003), ground combat (March 20, 2003, to April 30, 2003), and stabilization (May 1, 2003, to December 31, 2011).

Data used by the Statistical Analysis Cell were obtained and analyzed following strict data governance rules approved by the Army Human Research Protection Office: records were limited in scope to variables needed for the stated purposes and de-identified. All datasets were protected on secure DoD servers. Data analyses were performed using SAS version 9.1.3 software (SAS Institute, Inc, Cary, NC). *P*-values less than .05 were considered statistically significant.

The variability in 95th percentile daily DNBI/BI rates during the stabilization phase in OIF/OND was presented as percentage change compared to the first year of the stabilization phase. The overall change was presented as a fluctuation ratio between the largest and smallest DNBI/BI admission rates during the entire stabilization period. The top 5 principal ICD-9-CM diagnoses for each category of disease and injury type for US Army Soldiers hospitalized during the OIF/OND campaign were identified.

Because nontraditional populations were unknown, rates for these patients were defined in terms of US Army Soldiers population at risk. Using the new methodology developed by the SAC, ratios of the number of admissions for each group of patients to the number of Army Soldier admissions were multiplied by the 95th percentile Army

Soldier daily admission rate to estimate rates for nontraditional groups of patients (expressed per 1,000 Soldiers).

RESULTS

Rates for US Army Soldiers

Figures 1 and 2 present profiles of DNBI admissions and admission rates during buildup, ground combat, and the first year of stabilization in Operation Iraqi Freedom. These graphs reveal daily variability in the size of deployed troops and also in the number of hospital admissions during each phase of the campaign. Note that low admission counts (Figure 1) during the build-up phase equate to high admission rates (Figure 2) due to the relatively small number of deployed troops. Admissions and admission rates demonstrate descending trends for the stabilization phase. Results of the analysis performed for this phase show that each year's 95th percentile daily admission rate is more than 25% lower than the DNBI rate during the first year of stabilization. A fluctuation ratio of 1.45 illustrates an almost 50% difference between the lowest and the highest DNBI rate during the stabilization period. For the same period of time, the BI rates demonstrated much higher variability (fluctuation ratio was 4.3), and the 95th percentile daily BI admission rates for the last 3 years of OIF/OND decreased, on average, by almost 60%.

Table 1 presents 95th percentile daily admission rates for 3 recent campaigns. The DNBI rates for Iraq and Afghanistan are 47% and 27% lower than the DNBI rate for Desert Shield/Desert Storm. Table 2 presents the top 5 principal diagnoses in OIF/OND for each category: disease, nonbattle injury, and battle-injury. The top diagnosis for NBI is concussion, for BI is fracture of tibia and fibula, and for disease is symptoms involving chest and respiratory system.

Rates for Nontraditional Populations

Table 3 presents results of the casualty estimation for nontraditional populations for the entire OIF/OND campaign. Analysis conducted by phase showed that for each Soldier admitted during the stabilization period, there was over one patient from the nontraditional categories admitted to Role 3 Army MTFs. This ratio is even more pronounced for BI patients (more than 2 nontraditional patients admitted for each admitted US Army Soldier).

COMMENT

This paper presents the methodology behind the current DNBI/BI medical planning factors accredited by the Army Surgeon Generals and used in consecutive Total Army Analysis requirements for over a decade. Use of data from actual deployments as the basis for the casualty estimation of DNBI/BI rates greatly improved their

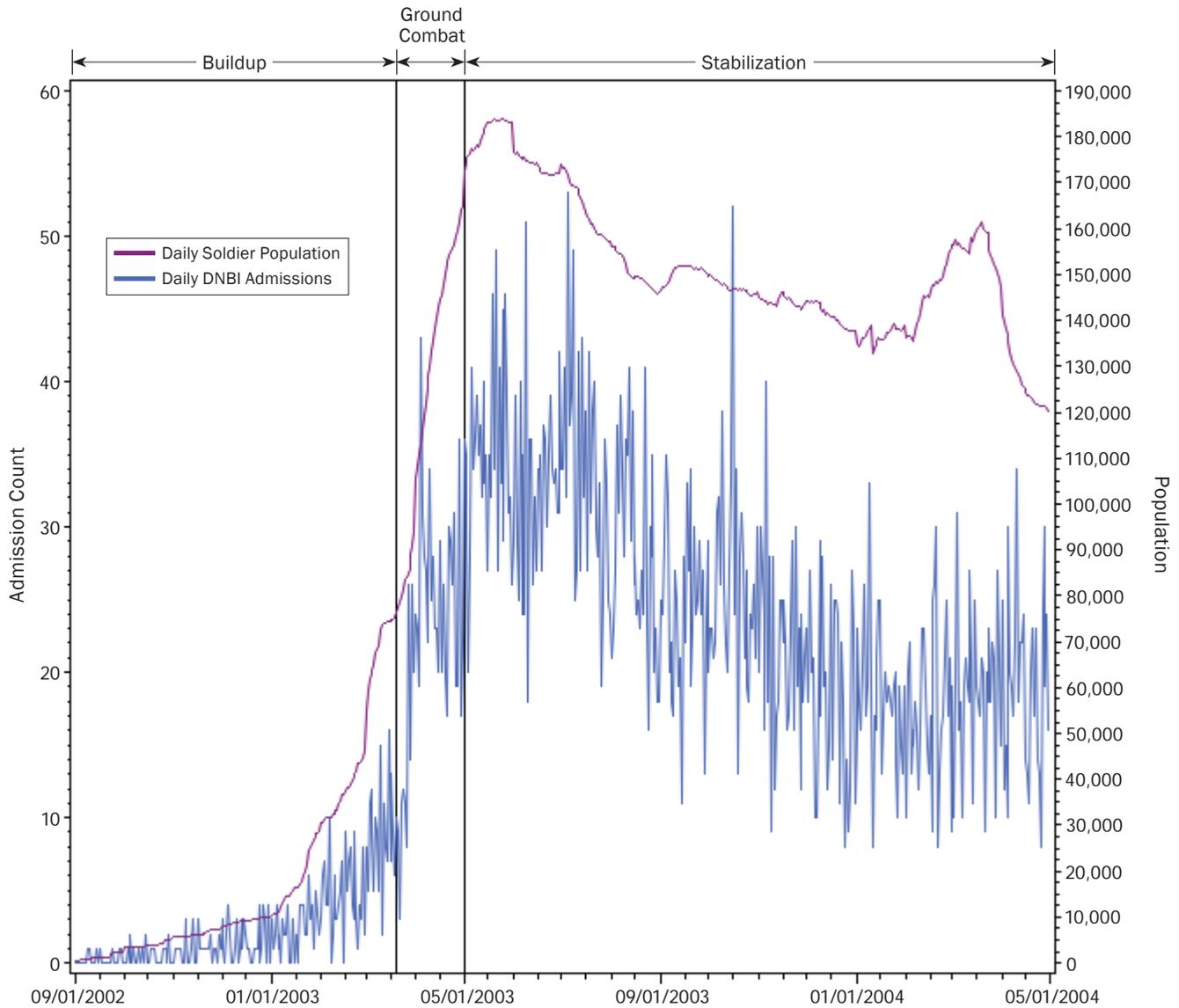


Figure 1. Daily admissions of US Army Soldiers for disease and nonbattle injuries and daily Soldier population at risk in Operation Iraqi Freedom through first year of Stabilization (April 30, 2004).

accuracy compared with previous planning tools which relied primarily on subject matter expert opinions. The DNBI/BI casualty estimation rates were validated by comparison to the most recently available data from current deployments. The methodology along with the SAS programming code was internally and externally verified and validated. The Center for Army Analysis used these rates to update Combat Support Hospital Rules of Allocation. As a consequence, the total number of beds and the total number of medical staff were corrected to account for nontraditional groups of patients. Prior to the analysis performed by the Statistical Analysis Cell, these patients were not included in the TAA process and the medical workload did not account for treating patients other than US Army Soldiers.

The continuous update of DNBI/BI rates is crucial for the accuracy of the casualty estimates. Our analysis is based on both healthcare administrative data from the SIDR housed by PASBA, and the Contingency Tracking System files capturing the US Army deployed Soldier population from DMDC. Both files are still subject to updates, changes, and corrections to the existing records. As a result, our estimates change, which is reflected in planning factors for consecutive TAA cycles.

Comparison of the DNBI/BI rates currently in use to the rates originally used in the TAA 11 based on the Desert Shield/Desert Storm experience emphasizes the effectiveness of the recent strategic approaches regarding force health protection, including Soldier readiness,

SETTING THE STAGE

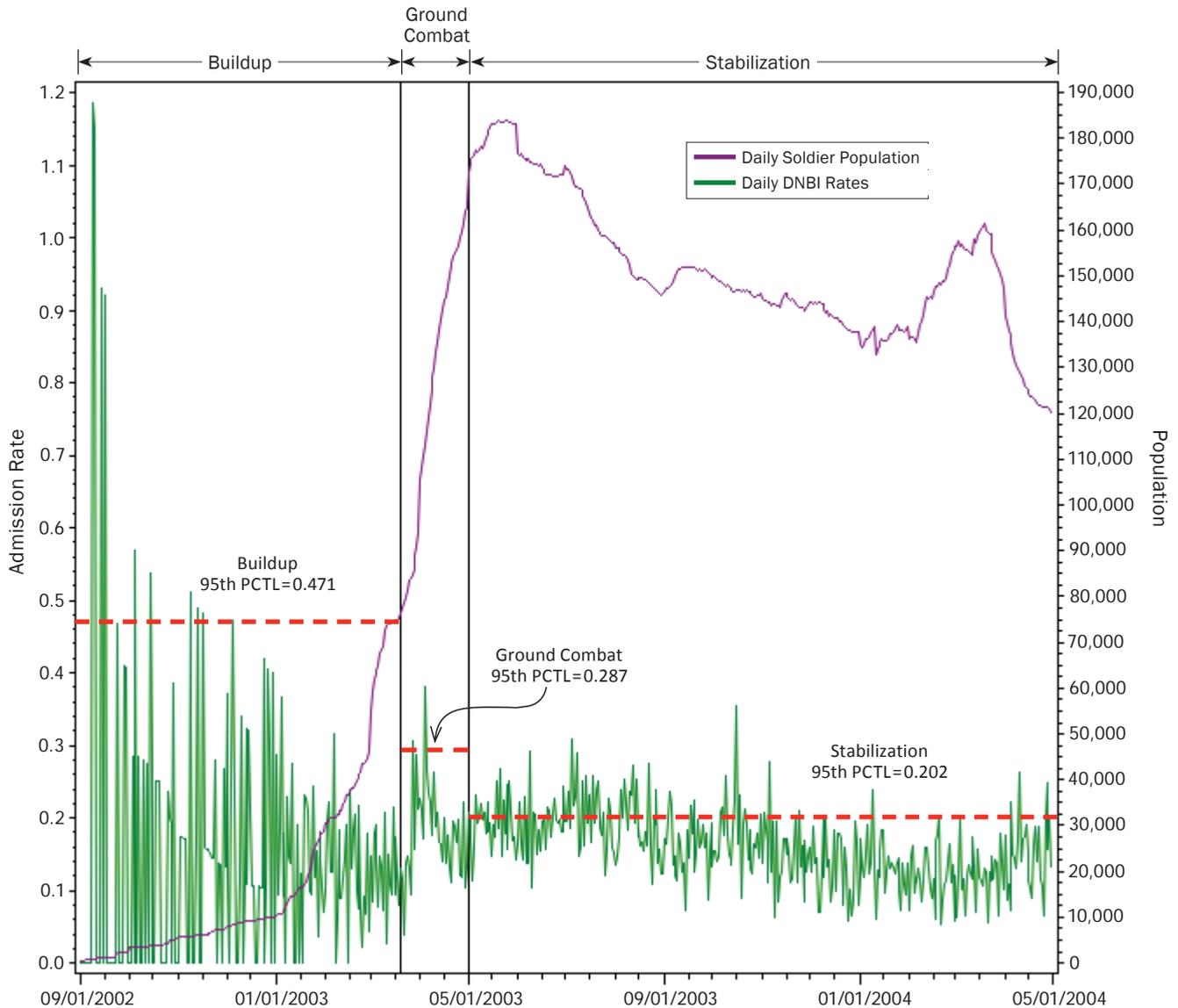


Figure 2. Daily admission rates (per 1,000 Soldiers) for disease and nonbattle injuries and daily Soldier population at risk in Operation Iraqi Freedom through first year of Stabilization (April 30, 2004), with 95th percentile (PCTL) phase rates.

new and/or improved personal protection equipment, personal physical fitness, camp sanitation measures, improved medical screening, environmental surveillance of the deployment destination, and more.¹¹ For example, for TAA 11, the 95th percentile daily DNBI rate for the ground combat phase based on DS/DS was 0.590/1,000 Soldiers. In recent TAA analysis, this rate is 0.287/1,000 Soldiers. The 95th percentile daily DNBI rate for stabilization was 0.370/1,000 Soldiers for DS/DS and now is 0.202/1,000 Soldiers based on OIF/OND data.

During the last decade, DNBI rates in OIF/OND decreased by 25% compared to the first year of stabilization, and BI rates decreased in the last 3 years of the campaign by almost 60%. These decreasing trends

demonstrate the effectiveness of Army initiatives to protect deployed Soldiers.

To fully embrace challenges regarding readiness of deployed troops, dental emergency encounters or D-DNBI incidence rates must be included in the planning process. In recent campaigns, dental emergency rates exceeded medical DNBI rates.^{12,13} Dental emergencies in a deployed setting may compromise combat effectiveness of deployed Soldiers, which is why medical planners need accurate estimates of D-DNBI rates to properly determine the amount of equipment, supplies, and manpower.

The DNBI casualty estimation methodology allowed us to conduct numerous epidemiological studies regarding

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Table 1. Campaign Comparison of 95th Percentile Daily Admission Rates (per 1,000 US Army Soldiers).

Campaign	Disease	NBI	DNBI	Population at Risk (total Soldier days)
Desert Shield/Desert Storm ^a	0.307	0.110	0.392	55,757,089
Operations Iraqi Freedom/New Dawn ^b	0.166	0.071	0.208	404,439,909
Operation Enduring Freedom ^c	0.227	0.122	0.285	130,098,331

^aEntire campaign
^bThrough 31 Dec 2011 (the end of OND)
^cThrough 31 Dec 2012

Table 2. Top 5 Principal Diagnoses^a for In-theater Admissions in Operations Iraqi Freedom/New Dawn^b by Admission Category.

Disease		Nonbattle Injury		Battle Injury	
Diagnosis	%	Diagnosis	%	Diagnosis	%
786 Symptoms involving respiratory system and other chest symptoms	6.81	850 Concussion	5.74	823 Fracture of tibia and fibula	5.11
592 Calculus of kidney and ureter	4.72	802 Fracture of face bones	4.37	863 Injury to gastrointestinal tract	4.69
682 Other cellulitis and abscess	4.22	824 Fracture of ankle	3.88	891 Open wound of knee, leg [except thigh], and ankle	4.35
540 Acute appendicitis	4.19	959 Injury, other and unspecified	3.88	890 Open wound of hip and thigh	4.28
780 General symptoms (Alteration of consciousness)	4.02	823 Fracture of tibia and fibula	3.78	873 Other open wound of head	3.65

^a3-digit ICD-9-CM diagnosis code
^bThrough 31 Dec 2011 (the end of OND)

Table 3. OIF/OND DNBI Admission Ratios and Rates^a for all Patient Populations Compared to US Army Soldiers.

Patient Category	Ratio to Army Admissions	95% Army Daily Admission Rate per 1,000 Soldiers	Rate per 1,000 US Army Soldiers
US Army		0.208	
Other US uniformed services	0.166		0.035
Coalition forces NATO	0.069		0.014
Coalition forces non-NATO	0.014		0.003
US government agencies and civilians	0.019		0.004
Contract employees	0.274		0.057
Indigenous population	0.174		0.036
Detainees	0.278		0.058
Other	0.0004		0.0001
Total (excluding US Army)	0.9944		0.207

^aThrough 31 Dec 2011 (the end of OND)

Soldiers' readiness in both OEF and OIF/OND. These studies cover a wide spectrum of healthcare topics, including behavioral health,¹⁴ traumatic brain injury,^{15,16} spinal cord injury,¹⁷ and dental emergencies.¹⁸

Continuation of the surveillance and updated analysis of both DNBI and BI hospital admission rates in recent theaters should provide more accurate estimates of both planning factors which are integral to AMEDD doctrine,

organization, training, materiel, leadership and education, personnel, and facilities development, and crucial for success of future operations.

REFERENCES

1. Peake JB. Reflections on injuries in the military. The hidden epidemic. *Am J Prev Med.* 2000;18(suppl 3):4-5.

SETTING THE STAGE

2. Kotwal RS, Wenzel RB, Sterling RA, Porter WD, Jordan NN, Petruccioli BP. An outbreak of malaria in U.S. Army Rangers returning from Afghanistan. *JAMA*. 2005;293(2):212-216.
3. Blood CG, Jolly R. Comparisons of disease and nonbattle injury incidence across various military operations. *Mil Med*. 1995;160(5):258-263.
4. Jones BH, Hansen BC. An Armed Forces Epidemiological Board evaluation of injuries in the military. *Am J Prev Med*. 2000;18(suppl 3):14-25.
5. Belmont PJ, Goodman GP, Waterman B, DeZee K, Burks R, Owens BD. Disease and nonbattle injuries sustained by a U.S. Army Brigade Combat Team during Operation Iraqi Freedom. *Mil Med*. 2010;175:469-476.
6. Lynch LC, Elliott CW, McMurry P. Disease and nonbattle injury forecasting. *US Army Med Dep J*. July-September 1999:2-8.
7. Amoroso PJ, Smith GS, Bell NS. Qualitative assessment of cause-of-injury coding in U.S. military hospitals: NATO standardization agreement (STANAG) 2050. *Amer J Prev Med*. 2000;18(suppl 3):174-187.
8. Wojcik BE, Davis JM, Humphrey RJ, Stein CR, Hassell LH. *AMEDD Disease And Non-battle Injury Models*, Fort Sam Houston, TX: United States Army Medical Department Center and School; January 2005. RP 05-001.
9. Wojcik BE, Hassell LH, Humphrey RJ, Davis JM, Oakley CJ, Stein CR. A disease and non-battle injury model based on Persian Gulf war admission rates. *Am J Ind Med*. 2004;45(6):549-557.
10. Wojcik BE, Humphrey RJ, Czejdo B, Hassell LH. U.S. Army disease and nonbattle injury model, refined in Afghanistan and Iraq. *Mil Med*. 2008;173(9):825-835.
11. Hyams KC, Riddle J, Trump DH, Wallace MR. Protecting the health of United States military forces in Afghanistan: applying lessons learned since the Gulf War. *Clin Infect Dis*. 2002;34(suppl 5):S208-S214.
12. Wojcik BE, Szeszel-Fedorowicz W, Humphrey RJ, et al. Risk of dental disease non-battle injuries and severity of dental disease in deployed U.S. Army personnel. *Mil Med*. 2015;180(5):570-577.
13. Simecek JW, Colthirst PM, Wojcik BE, Eikenberg S, Guerrero AC, Fedorowicz A, Szeszel-Fedorowicz W, DeNicolo P. The incidence of dental disease non-battle injuries in deployed U.S. Army personnel. *Mil Med*. 2014;179(6):666-673.
14. Wojcik BE, Akhtar FZ, Hassell LH. Hospital admissions related to mental disorders in U.S. Army soldiers in Iraq and Afghanistan. *Mil Med*. 2009;174(10):1010-1018.
15. Wojcik BE, Stein CS, Bagg K, Humphrey RJ, Orosco J. Traumatic brain injury hospitalizations of U.S. Army soldiers deployed to Afghanistan and Iraq. *Amer J Prev Med*. 2010;38(suppl):S108-S116.
16. Wojcik BE, Stein CS, Orosco J, Bagg K, Humphrey RJ. Creation of an expanded Barell Matrix to identify traumatic brain injuries of U.S. military members. *Journal of Defense Modeling and Simulation: Applications, Methodology, Technology*. 2010;7:157-166. Available at: <http://dms.sagepub.com/content/7/3.toc>. Accessed January 19, 2016.
17. Wojcik BE, Curley KC, Szeszel-Fedorowicz W, Stein CR, Humphrey RJ. Spinal injury hospitalizations among U.S. Army soldiers deployed to Iraq and Afghanistan. *Mil Med*. 2015;180(2):216-223.
18. Colthirst PM, Wojcik BE, Humphrey RJ, Hosek B, Stein CR, Landt C. Longitudinal Analysis of Dental Emergencies in Overseas Contingency Operations. Poster presented at: National Oral Health Conference; April 27-29, 2015; Kansas City, MO.

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Surveillance of Disease and Nonbattle Injuries During US Army Operations in Afghanistan and Iraq

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ABSTRACT

Disease and nonbattle injury (DNBI) are the leading causes of morbidity during wars and military operations. However, adequate medical data were never before available to service public health centers to conduct DNBI surveillance during deployments. This article describes the process, results and lessons learned from centralized DNBI surveillance by the US Army Center for Health Promotion and Preventive Medicine, predecessor of the US Army Public Health Command, during operations in Afghanistan and Iraq (2001-2013). The surveillance relied primarily on medical evacuation records and in-theater hospitalization records. Medical evacuation rates (per 1,000 person-years) for DNBI were higher (Afghanistan: 56.7; Iraq: 40.2) than battle injury rates (Afghanistan: 12.0; Iraq: 7.7). In Afghanistan and Iraq, respectively, the leading diagnostic categories for medical evacuations were nonbattle injury (31% and 34%), battle injury (20% and 16%), and behavioral health (12% and 10%). Leading causes of medically evacuated nonbattle injuries were sports/physical training (22% and 24%), falls (23% and 26%) and military vehicle accidents (8% and 11%). This surveillance demonstrated the feasibility, utility, and benefits of centralized DNBI surveillance during military operations.

Historically, disease was the greatest threat to Soldiers' health and the leading cause of death in early American wars, including World War I. During World War II, there was a transition to a more mechanized Army. There were also significant advances in sanitary and medical control of infectious diseases.^{1,2} As a result, for the first time in history, the Army fatality rate for disease and nonbattle injury (DNBI) combined (74/10,000 Soldiers) was much lower than the rate for battle injury (209/10,000 Soldiers).³

Unlike the fatality rate, the hospitalization rate for DNBI in World War II was still much higher (669/1,000 person-years [p-years]) than the rate for battle injury (29/1,000 p-years), due primarily to disease (592/1,000 p-years).⁴ Even though DNBI and battle injury rates dropped significantly in Viet Nam and again in Operations Desert Shield and Desert Storm (the Gulf War, 1990-1991), the DNBI hospitalization rate was still higher than the battle injury rate in the Gulf War (152/1,000 p-years and 6/1,000 p-years, respectively).^{4,5} Of the DNBI hospitalizations in the Gulf War, the 2 leading diagnosis categories were acute nonbattle injury and conditions of the musculoskeletal system, accounting for 25% and 13% of hospitalizations, respectively.⁶

After 13 years of continuous military operations in Afghanistan and Iraq, the Army is rapidly transforming

from a force focused on counterinsurgency operations to a smaller force that will be more adaptable, mobile, and responsive to global threats.^{7,8} In the future, there will be an ever greater dependence on the personal medical readiness of every Soldier. In this rapidly changing operational setting, every casualty, whether from battle injury or DNBI, will impact unit and mission readiness. Even more than now, commanders will rely on near-real time DNBI surveillance to assess medical readiness of the force and identify emerging medical threats.^{1,2,9}

In past military deployments and conflicts, up to and including Operations Desert Shield and Desert Storm, the military services had no systematic, theater-wide DNBI surveillance.⁵ Reported DNBI patterns, rates, and trends were based on analysis of hospitalization records that were centrally collected after the deployments ended.⁵ The absence and importance of a systematic DNBI surveillance program were realized when there were insufficient medical and environmental surveillance data to evaluate possible causes of adverse health effects reported by veterans of the Gulf War.¹⁰

In 1993, the Joint Staff mandated medical surveillance with weekly DNBI reporting on future joint deployments.^{5,11} A theater-wide program for collecting outpatient data for DNBI surveillance was in place for deployments to Somalia (Operation Restore Hope, 1992-1993),

Haiti (Operation Uphold Democracy, 1994), and Egypt (Bright Star training exercise, 1994). But these surveillance data were incomplete and nonspecific.⁵ This same Joint Staff DNBI surveillance was still in place in October 2001 when Operation Enduring Freedom began in Afghanistan.

IMPROVEMENTS IN DNBI SURVEILLANCE DURING OPERATIONS IN AFGHANISTAN AND IRAQ

In 2003, the Deployment Health Support Directorate (Office of the Secretary of Defense) fielded the Theater Medical Information Program (TMIP), a layered force health protection data system.¹⁰ The Joint Medical Workstation (JMeWS), an element of TMIP fielded in January 2003, provided online, near real-time medical surveillance and analysis derived from patient records and DNBI reports.^{10,12} Later, TMIP added the Medical Situational Awareness in the Theater (MSAT) and Theater Medical Data Store (TMDS) web-based applications that allow both classified and unclassified access to theater medical records and other medical data.¹³⁻¹⁵ Numerous system updates contributed to improvements in the theater medical surveillance capability during the operations in Afghanistan and Iraq.¹⁵ Updates to components of the electronic health record, including AHLTA-Theater and Theater Composite Health Care System Cache, improved the capture of outpatient and inpatient medical encounters, respectively. Improvements in the theater informatics infrastructure allowed greater connectivity and access to these systems. But even with these improvements, concerns persisted about the completeness and accuracy of the in-theater DNBI surveillance capability and the medical encounters in the electronic health record.

In early 2004, the US Army Center for Health Promotion and Preventive Medicine (USACHPPM), predecessor of the US Army Public Health Command (USAPHC) developed and implemented a plan for centralized DNBI surveillance for the operations in Afghanistan and Iraq. This surveillance plan included identifying and coding causes of nonbattle injury to monitor rates and trends over time. This article describes the process used by the USACHPPM and USAPHC for centralized DNBI surveillance for operations in Afghanistan and Iraq; summarizes findings from the surveillance; and describes surveillance lessons learned.

METHODS

The Injury Prevention Program at USACHPPM identified and evaluated medical and nonmedical data systems for their potential contribution to centralized, systematic DNBI surveillance. It evaluated the data systems initially in 2004, and reevaluated them periodically as

changes and improvements were made. Using data completeness, accuracy, accessibility, timeliness, and utility as criteria, the following data systems were evaluated:

- ▶ Medical encounter data from theater accessed through MSAT and TMDS
- ▶ Standard Inpatient Data Records (SIDR) from in-theater hospitalizations provided by the Patient Administration System and Biostatistics Activity (PASBA), Office of the Surgeon General
- ▶ Medical evacuation records from the Transportation Command Regulating and Command & Control Evacuation System (TRAC2ES)
- ▶ Casualty records from the Defense Casualty Information Processing System
- ▶ Accident records from the Army Safety Management Information System

The USACHPPM concluded from this evaluation that TRAC2ES and hospitalization records were best suited for centralized surveillance. The data from TRAC2ES were complete (*all* medical evacuations from theater), accurate, accessible (through the TRAC2ES portal), timely (data entered at the time of evacuation), and useable (ie, unique personal identifiers, ICD-9-CM* diagnosis codes, and patient histories from which causes of nonbattle injury could be determined). Also considered was the fact that Soldiers requiring evacuation from theater have serious medical conditions and are a “loss” to their unit until they return to theater or are replaced. Each loss negatively affects the unit’s mission readiness related to the operational tempo and special skills of each Soldier. While hospitalization records were judged to be accurate and useable, they were not accessible until 4 to 6 months after the hospitalization occurred.

The USACHPPM evaluation of the remaining data sources (ie, theater outpatient encounters, casualty records, and accident records) determined that they should be used only as secondary data sources. Due to theater-related issues, the outpatient encounter data were incomplete and the representativeness of available data could not be determined. These encounter data were used to investigate some specific medical problems, but were not used in the centralized surveillance. Casualty and accident records were valuable in providing additional details about the causes and mechanisms of some injuries.

For rate calculations used in the surveillance, the Armed Forces Health Surveillance Center provided the denominator data (number of deployed person-months) for each month of the deployments. These data were based on the

*International Classification of Diseases, 9th Revision, Clinical Modification

Contingency Tracking System data from the Defense Manpower Data Center.

RESULTS OF CENTRALIZED DNBI SURVEILLANCE

Medical Evacuations

Overall, 20,702 Soldiers were medically evacuated from Operation Enduring Freedom (OEF: October 2001 to December 2013) and 47,647 Soldiers were evacuated from Operation Iraqi Freedom-New Dawn (OIF-OND: March 2003 to December 2011). Medical evacuation rates in OEF for disease, nonbattle injury, and battle injury were 28.6/1,000 p-years, 18.1/1,000 p-years, and 12.0/1,000 p-years, respectively. In OIF-OND, these rates were lower than in OEF (24.0/1,000 p-years, 16.3/1,000 p-years, and 7.7/1,000 p-years, respectively).

Figures 1A and 1B show the monthly rates for DNBI (blue line) and battle injury (red line) medical evacuations from OEF and OIF-OND, respectively. Monthly rates were highest during the initial phases the operations. After the initial phases, monthly DNBI rates in OEF were generally higher (range after 2002: 21/1,000 p-years to 93/1,000 p-years) than in OIF (range after 2003: 20/1,000 p-years to 70/1,000 p-years). Monthly battle injury rates in OEF were lower prior to May 2006 compared to the period June 2006 to December 2011. Battle injury rates after June 2006 in OEF followed a seasonal pattern with higher rates between April and September reflecting higher levels of hostile action during the warmer months. In OIF-OND, monthly battle injury rates were higher during the first half of the operation (March 2003 to May 2008; range: 5 to 25/1,000 p-years) compared to the period June 2008 to December 2011 (range: 0 to 5/1,000 p-years).

Figures 2A and 2B show the distribution of medical evacuations for each operation by primary diagnosis groups in the ICD-9-CM. The pattern for distribution is similar for both operations. The 2 leading diagnosis categories for OEF and OIF-OND were nonbattle injury (ie, acute injuries and injury-related musculoskeletal conditions) accounting for 31% and 34%, respectively, of medical evacuations, and battle injury, accounting for 20% and 16%, respectively, of evacuations. The next 3 leading categories for OEF and OIF-OND were behavioral health (12% and 10%, respectively), ill-defined conditions (8% and 9%, respectively), and digestive disorders (6% for both operations).

Figures 3A and 3B show the annual percentage of all medical evacuations for each of the 6 leading diagnosis groups from Figures 2a and 2b. Evacuations for nonbattle injury fluctuated in both operations. The percentage of battle injury evacuations in OEF increased starting in

2006, whereas the battle injury percentage in OIF-OND was increasing from 2003 to 2007 and then dropped from 2008 to 2013. For both operations, the percentage of evacuations for behavioral health increased beginning in 2007, peaking at 18% in OEF (2012) and 21% in OIF-OND (2010).

Figure 4 shows the leading causes of nonbattle injuries that required medical evacuation, as determined from the patient history in TRAC2ES records. The leading causes of nonbattle injury were similar for both operations, though the rank order of the causes differed by operation. Sports and physical training accounted for 24% and 22% of nonbattle injury evacuations in OIF-OND and OEF, respectively. Falls and near-falls accounted for 23% of evacuations in OIF-OND and 26% in OEF. Military motor vehicle accidents accounted for 11% and 8% of nonbattle injury evacuation in OIF-OND and OEF, respectively.

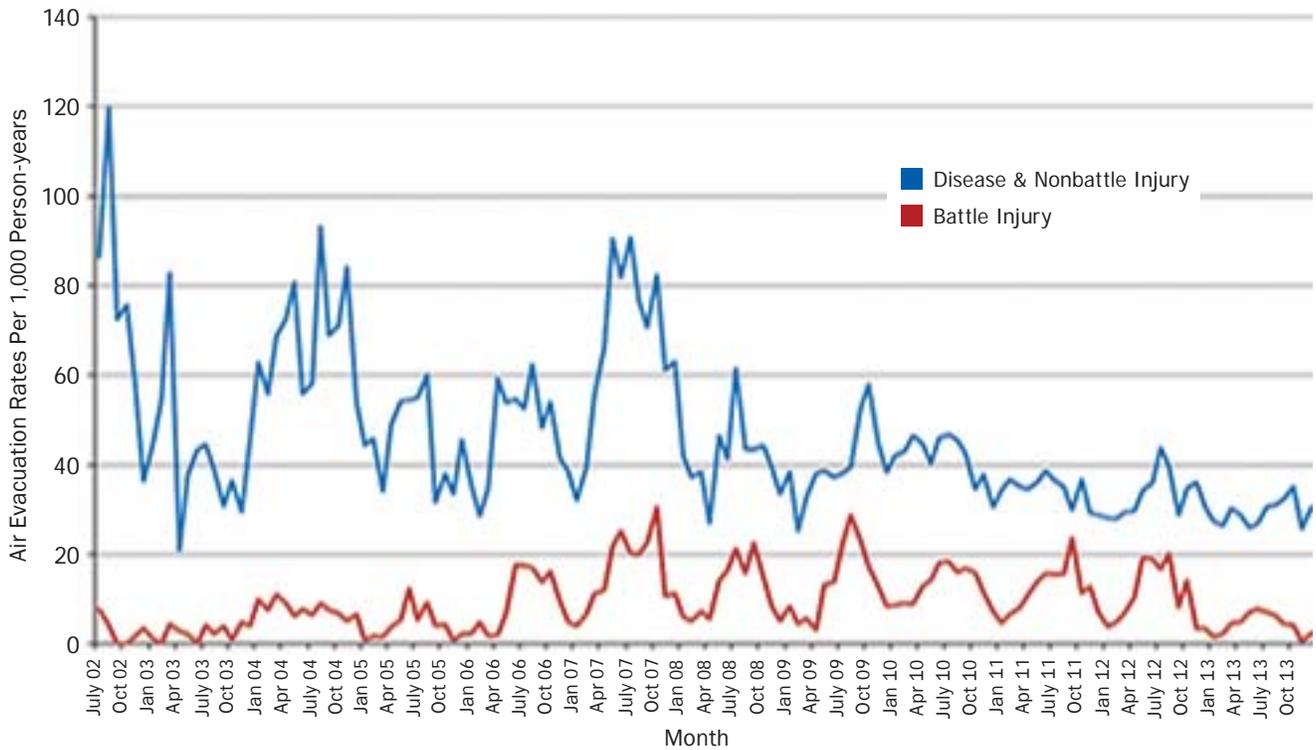
In-theater Hospitalizations

Overall, there were 12,251 hospitalizations in OEF and 23,299 hospitalizations in OIF-OND. Hospitalization rates for disease, nonbattle injury, and battle injury in OEF were 16.1/1,000 p-years, 6.2/1,000 p-years, and 12.3/1,000 p-years, respectively. In OIF-OND, hospitalization rates for disease and nonbattle injury (26.3/1,000 p-years and 8.8/1,000 p-years, respectively), were higher than in OEF, but the rate for battle injury (9.1/1,000 p-years) was lower.

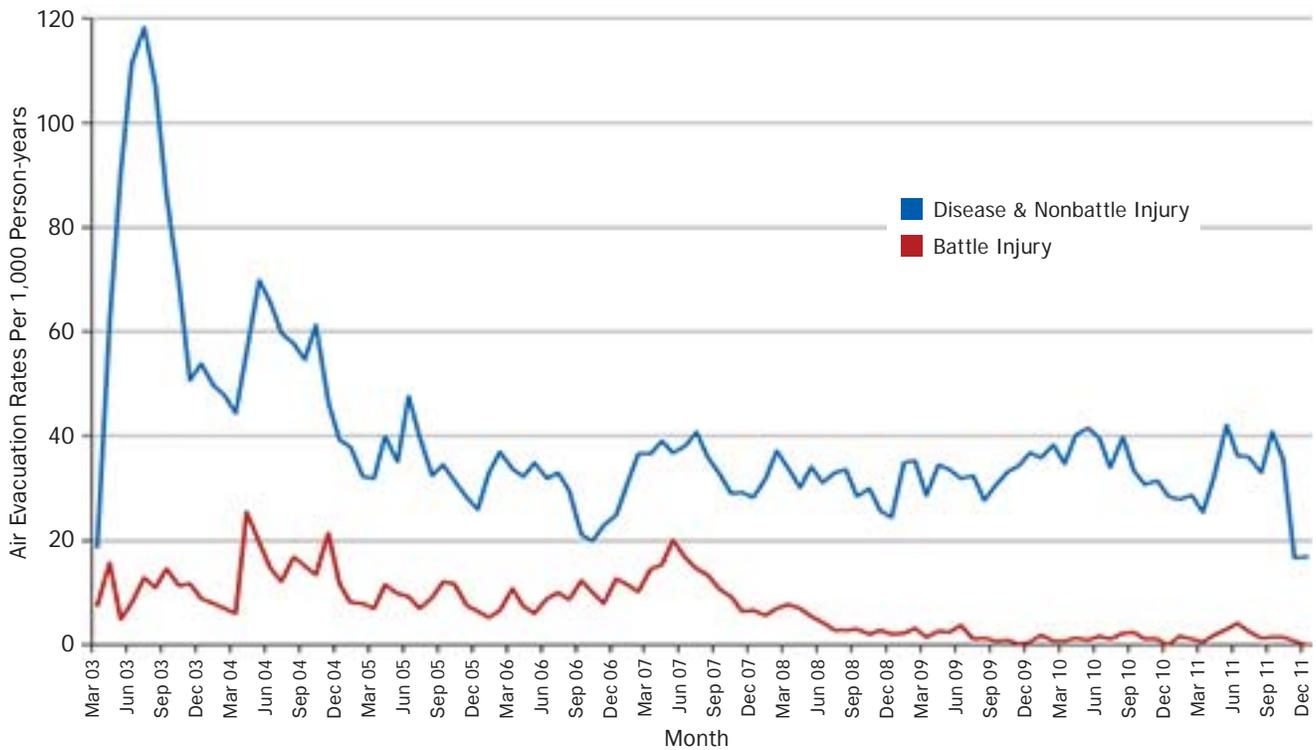
The distribution of primary diagnosis groups for in-theater hospitalizations differed from the distribution for medical evacuations. For OEF and OIF-OND, the 4 leading diagnosis groups for hospitalizations were battle injury (36% and 21%, respectively), nonbattle injury (18% and 19%, respectively), digestive disorders (11% and 15%, respectively) and ill-defined conditions (10% for both operations). Whereas behavioral health ranked third for medical evacuations in both operations (18% to 21%), it ranked eighth for OEF hospitalizations (3.0%) and sixth for OIF-OND hospitalizations (6%).

The distribution of causes of nonbattle injuries hospitalized in-theater also differed from the distribution for nonbattle injuries that were medically evacuated. The 2 leading causes of nonbattle injury hospitalizations for OEF and OIF-OND were military vehicles (21% for both operations) and falls (21% and 15%, respectively). Inhalation or ingestion of toxic substances (intentional injuries) ranked fourth for OEF (11%) and third for OIF-OND (13%). Sports and physical training ranked fifth for hospitalizations but was the leading category for nonbattle injury medical evacuations.

SETTING THE STAGE



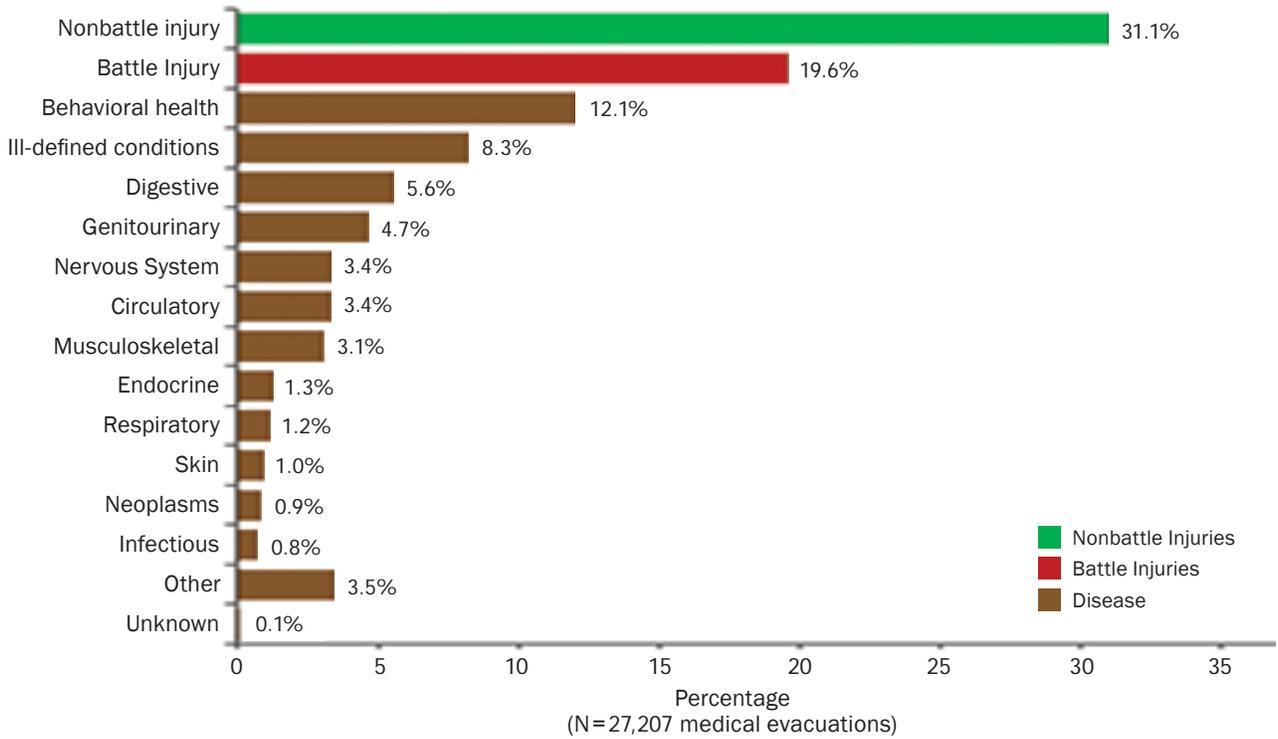
1A. Operation Enduring Freedom (July 2002 - October 2013).



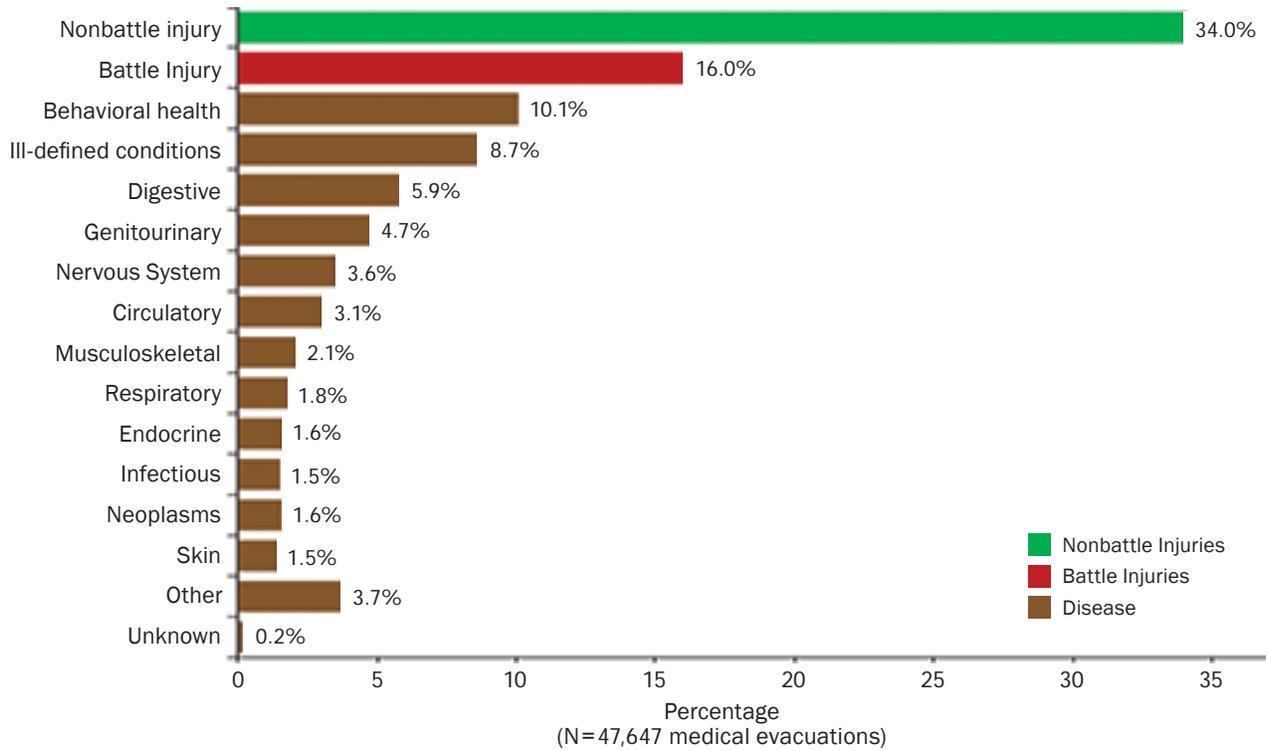
1B. Operation Iraqi Freedom - New Dawn (March 2003 - December 2011).

Figure 1. Monthly rates (per 1,000 person-months) for medical evacuation of battle injuries and disease/nonbattle injuries for Operation Enduring Freedom (1A) and Operation Iraqi Freedom - New Dawn (1B).

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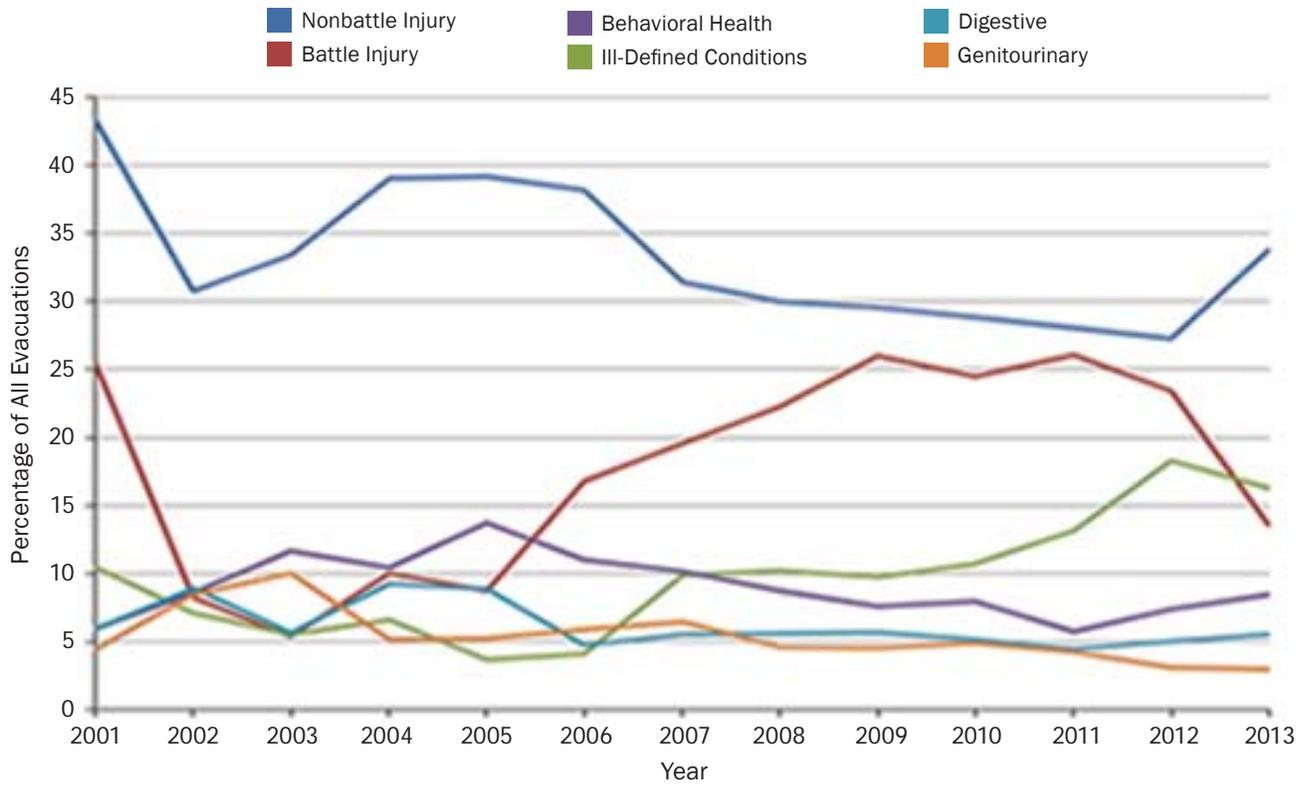
2A. Operation Enduring Freedom (2001 - 2013).



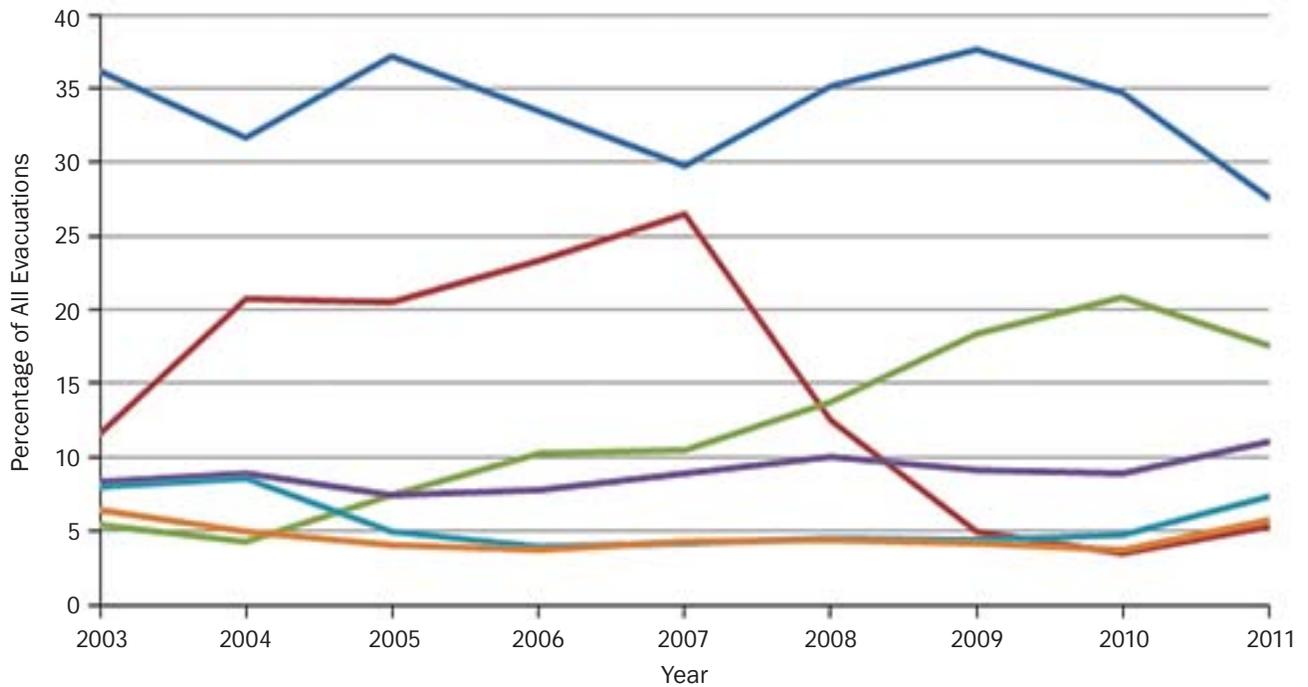
2B. Operation Iraqi Freedom - New Dawn (2003 - 2011).

Figure 2. Distribution of primary diagnosis categories for US Army medical evacuations from Operation Enduring Freedom (2A) and Operation Iraqi Freedom - New Dawn (2B).

SETTING THE STAGE



3A. Operation Enduring Freedom (2001 - 2013).



3B. Operation Iraqi Freedom - New Dawn (2003 - 2011).

Figure 3. Percentages of US Army medical evacuations for the leading primary diagnosis categories from Operation Enduring Freedom (3A) and Operation Iraqi Freedom - New Dawn (3B).

COMMENT

The USACHPPM/USAPHC conducted centralized DNBI surveillance during the operations in Afghanistan and Iraq. This surveillance used medical evacuation and in-theater hospitalization records as primary data sources. A unique component of the surveillance was coding causes of nonbattle injuries based on the narrative patient history in TRAC2ES records. This surveillance demonstrated the feasibility and utility of identifying causes of nonbattle injury from medical evacuation and hospitalization records.

Operation Enduring Freedom and OIF-OND were the first Army operations of this scale in which data were available to conduct centralized DNBI surveillance during the operations. This surveillance provided an additional means of monitoring health of the force and identifying emerging medical threats. As for nonbattle injuries, this surveillance helped to focus attention on potentially preventable causes of injury such as falls from tactical vehicles, rollover tactical vehicle accidents, and injuries from sports and physical training.

Distributions for the primary diagnosis groups for medical evacuations were similar for both operations. The 3 leading diagnosis groups were nonbattle injury, battle injury, and behavioral health. The leading diagnosis groups for in-theater hospitalizations were also similar for both operations (ie, battle injury, nonbattle injury, and digestive), but the rank order and proportion for the leading diagnosis groups were different for hospitalizations compared to medical evacuations. In-theater medical capabilities and individual prognosis likely influenced these differences.

LESSONS LEARNED FROM DNBI SURVEILLANCE IN AFGHANISTAN AND IRAQ

As the Army transforms to a smaller, yet more adaptable, mobile, and responsive force, senior leaders and commanders will have a greater expectation for near real-time DNBI surveillance to accurately assess the medical readiness of the force and identify emerging medical threats.^{1,2,9} Lessons learned from surveillance during OEF and OIF-OND should guide efforts in the Department of Defense and Army as they work toward a more robust and informative DNBI surveillance for the future. Lessons learned from this surveillance follow:

- Central DNBI surveillance was achieved using medical evacuation (TRAC2ES) and in-theater hospitalization (SIDR-PASBA) records.

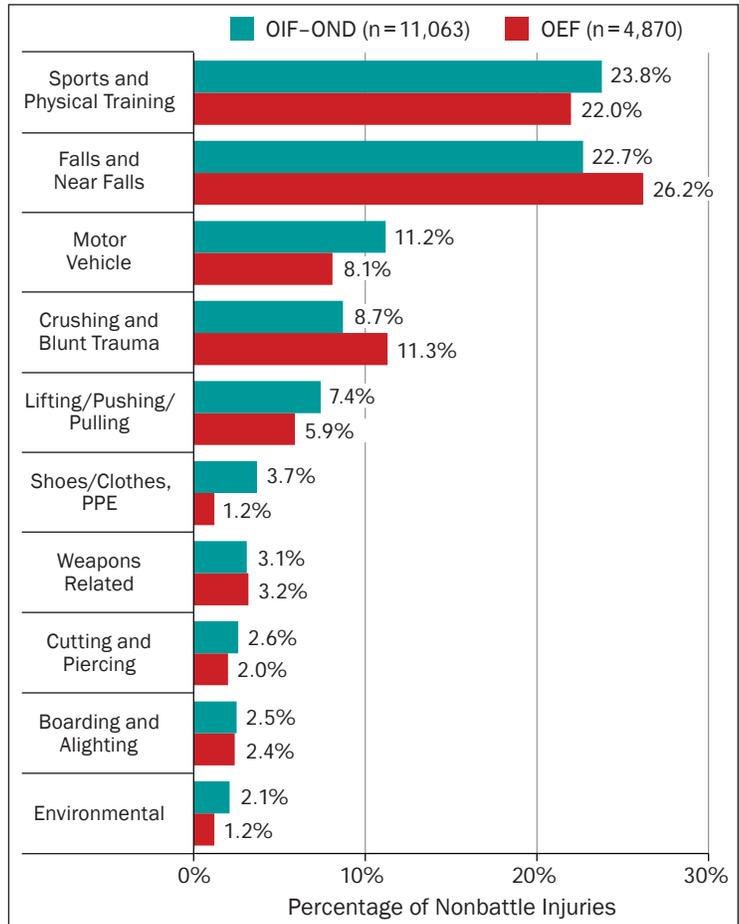


Figure 4. Causes of US Army nonbattle injuries requiring medical evacuations from Operation Enduring Freedom (OEF), 2001-2013, and Operation Iraqi Freedom - New Dawn (OIF-OND), 2003-2011.

- Utility of MSAT for centralized DNBI surveillance was limited because it could only be accessed on the classified network. As such, MSAT data could not be analyzed or linked to other medical and non-medical surveillance data that reside on unclassified systems.
- Air evacuation records from TRAC2ES were used to identify and code causes of nonbattle injury. In-theater SIDR hospitalization records from PASBA included coded causes of injury.
- The deployment outpatient encounter data in MSAT did not have coded causes of injury. Currently, injury cause coding in the electronic health record by medical providers is not mandatory in the electronic health records. As a result, causes of injury are unknown for injuries treated at levels I and II where the majority of injured Soldiers receive medical care. Finding a solution to this important shortfall in the health record should be a priority.
- Nonbattle injury was the leading diagnostic category of medical evacuations in both operations,

followed by battle injury. Of in-theater hospitalizations, battle injury was the leading category, followed by nonbattle injury. These data show that injuries are a leading medical problem during deployments and affect unit and mission readiness.

- Leading causes of nonbattle injury during deployments were the same as leading causes among Soldiers in garrison. Whether in garrison or on deployment, the 3 leading causes of injury for hospitalized nonbattle injuries are motor vehicle accidents, falls, and sports/physical training.¹⁶ The leading cause of air evacuated nonbattle injuries was sports/physical training, which is also the leading cause of injuries among Soldiers in garrison.^{17,18}

CENTRAL AND IN-THEATER DNBI SURVEILLANCE ISSUES RELATED TO DOCTRINE, ORGANIZATION, TRAINING, MATERIEL, LEADERSHIP & EDUCATION, PERSONNEL, AND FACILITIES

Doctrine

- ♦ Policy and directives should include the requirement for entering medical care in the electronic medical record at all levels of medical care in theater. Despite improvements during OEF and OIF-OND, no outpatient medical encounters were entered in the electronic medical record during the most recent operation in Africa (Operation United Assistance, 2014-2015).
- ♦ Consideration should be given to allow greater access to deployment medical encounter and population data from MSAT on unclassified systems to support military public health centers in medical surveillance and force health protection work.

Training

- ♦ Active and reserve component medical units should receive predeployment training on the medical information technology systems they will use in theater (for example, Medical Communications for Combat Casualty Care [MC4] and JMeWS).

Facilities

- ♦ In-theater support for JMeWS/MSAT/MC4 systems is essential for data flow throughout the enterprise to those with a need-to-know. Reliable in-theater and central DNBI surveillance at all levels of care can only be achieved when the medical encounter data are complete and representative of the deployed population.

Leadership & Education

- ♦ Given the magnitude of the injury problem for the Army, senior medical and safety leaders should support mandatory cause-coding of injuries in the electronic health record.

REFERENCES

1. Sanders JW, Putnam SD, Frankart C, et al. Impact of illness and noncombat Injury during Operations Iraqi Freedom and Enduring Freedom (Afghanistan). *Am J Trop Med Hyg.* 2005;73(4):713-719.
2. Skeeahan CD, Tribble DR, Sanders JW, Putnam SD, Armstrong AW, Riddle MS. Nonbattle injury among deployed troops: an epidemiologic study. *Mil Med.* 2009;174:1256-1262.
3. Defense Casualty Analysis System, Defense Manpower Data Center. US Military Casualties: Conflicts 1775-1991 [internet]. Available at: https://www.dmdc.osd.mil/dcas/pages/report_principal_wars.xhtml. Accessed September 25, 2015.
4. Jones BH, Perrotta DM, Canham-Chervak ML, Nee MA, Brundage JF. Injuries in the military: a review and commentary focused on prevention. *Am J Prev Med.* 2000;18(suppl 3):71-84.
5. Writer JV. Deployment injuries. In: Kelly PW, ed. *Military Preventive Medicine: Mobilization and Deployment.* Vol 1. Fort Sam Houston, TX: Borden Institute; 2003:523-537.
6. Writer JV, DeFraités RF, Keep LW. Non-battle injury casualties during the Persian Gulf War and other deployments. *Am J Prev Med.* 2000;18(suppl 3):64-70.
7. Davidson RS. The vision: transformation of our cold war-era force. *Mil Intell.* 2000;26:5-8.
8. McHugh JM, Odierno RT. Army Strategic Planning Guidance 2013 [internet]. Available at: http://www.army.mil/e2/rv5_downloads/info/references/army_strategic_planning_guidance.pdf. Accessed September 23, 2015.
9. Peake JB. Reflections on injuries in the military: a hidden epidemic. *Am J Prev Med.* 2000;18(suppl 3):4-5.
10. DeNicola AD. Deployment surveillance. In: *NATO Medical Surveillance and Response, Research and Technology Opportunities and Options.* Report No. RTO-MP-HFM-108. 2004;9:1-9.10. Available at: <http://www.dtic.mil/dtic/tr/fulltext/u2/a433716.pdf>. Accessed September 24, 2015.
11. *Department of Defense Instruction 6490.3: Implementation and Application of Joint Medical Surveillance for Deployments.* Washington, DC: US Department of Defense; August 7, 1997. Available at: <http://biotech.law.lsu.edu/blaw/dodd/corres/pdf2/i64903p.pdf>. Access September 24, 2015.
12. Hooper TI, DeBakey SF, Bellis KS, Cox KL, Gackstetter GD. The Joint Medical Workstation (JMeWS) database in 2003: intradeployment health encounters of military personnel supporting Operations Enduring Freedom and Iraqi Freedom. *Mil Med.* 2008;173(2):119-128.

THE ARMY MEDICAL DEPARTMENT JOURNAL

13. Performance Military Health System Medical Situational Awareness in Theater/The Theater Medical Data Store [internet]. Reston, VA: Data Networks Corporation. Available at: <http://www.dncx.com/PDF%20Files/DHITS%202014%20-%20-%20MSAT%20TMDs%20Both%20Pages.pdf>. Accessed September 28, 2015.
14. Fact Sheet: Medical Situational Awareness in the Theater (MSAT) [internet]. Health Information Technology Directorate, Defense Health Agency. Available at: <http://www.health.mil/~media/MHS/Fact%20Sheet%20Files/DHCS/Theater/MSAT%20Factsheet.ashx>. Accessed September 23, 2015.
15. US Army Center for Health Promotion and Preventative Medicine. An assessment of current health surveillance capabilities in deployed settings. Paper presented at: Proceedings from a Tri-Service Symposium; July 18-22, 2005; Landstuhl, Germany.
16. Jones BH, Canham-Chervak M, Canada S, Mitchener TA, Moore S. Medical surveillance of injuries in the U.S. military: descriptive epidemiology and recommendations for improvement. *Am J Prev Med.* 2010;38(suppl):S42-S60.
17. Hauret KG, Bedno S, Loring K, Kao TC, Mallon T, Jones BH. Epidemiology of exercise- and sports-related injuries in a population of young, physically active adults: a survey of military servicemembers. *Am J Sports Med.* 2015;43(11):2645-2653.
18. Knapik JJ, Jones SB, Darakjy SD, Hauret KG, Bullock SH, Sharp MA, Jones BH. Injury rates and injury risk factors among US Army wheel vehicle mechanics. *Mil Med.* 2007;172:988-996.

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CHANGES IN EQUIPMENT AND TECHNIQUES/TACTICS/ PROCEDURES THAT IMPACTED CARE AND OUTCOMES

Dismounted Complex Blast Injuries Including Invasive Fungal Infections

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ABSTRACT

Large blast injuries during dismounted operations in southwest Afghanistan causing major limb amputations and perineal injuries associated with large blood volume resuscitation were associated with invasive fungal, primarily mold, infections. This article outlines the interventions undertaken to mitigate excess morbidity and mortality associated with invasive fungal infection. These interventions include defining the problem and associated risk with systemically collected and analyzed information, developing improved protective body armor for the thigh and perineal region, standardizing management through clinical practice guidelines that outlined risk, diagnostic and treatment recommendations with enhanced discussions on the weekly Theater Combat Casualty Care Conference that includes personnel from the combat zone, Germany, and the United States. The article concludes by explaining the key way forward with regarding an inner-war approach to sustained knowledge and skills.

BACKGROUND

Unprecedented knowledge and advances during the wars in Iraq and Afghanistan have improved survival rates, but at the same time led to increased morbidity.¹ As the enemy adjusted to US countermeasures, the military medical response had to adjust accordingly. Mechanisms of injury transitioned between small arms fire, mortars, rocket-propelled grenades and improvised explosive devices (IED). In addition, the military had to adjust from mounted to dismounted operations and from centralized larger bases to widely distributed smaller bases as the wars transitioned from ground combat operations to counterterrorism/counterinsurgency. This required utilization of the Combat Medic for unparalleled care at the point of injury. There was also the implementation of evacuation from time of injury to surgical care within an hour, leading to improved outcomes.² In addition, the US military developed advanced care nearer to the point of injury through flight paramedics and flight critical care nurses, reflecting the British Medical Emergency Response Team. The operational environment also changed from deserts in Iraq to rocky mountains and lush waterways in parts of Afghanistan. The culminations of these changes led to alterations in injury types and infecting pathogens requiring continual medical response adjustments.

Examples of military adjustments included equipment; tactics, techniques and procedures (TTPs); and clinical training and guidelines. Equipment advances to improve survival included tourniquet fielding with training, improved body armor, improved uniform design to survive thermal injury and improved vehicular design to minimize injury. New training courses such as the Tactical Combat Medical Care and the implementations of Clinical Practice Guidelines led to standardization of care and rapid fielding of the most current information and practices. Vital to every decision was the ability to collect information to improve the entire continuum of casualty care. The Department of Defense Trauma Registry (DoDTR) in combination with the Joint Trauma System allowed for rapid data collection, analysis, and distribution of new care guidelines. As infections occur in approximately 50% of casualties that were injured severely enough to be admitted to an ICU, the Infectious Disease (ID) Module was developed for the DoDTR with a separate Trauma Infectious Disease Outcome Study to analyze and collect 5-year outcome data.³

The recognition of the challenges with dismounted complex blast injuries in southwest Afghanistan were first noted by the British military as this was their primary area of responsibility prior to the US Army and Marine

Corps transitioning to the area.⁴ The British referred to this area as the “Green Zone” because of the vegetation and waterways which was often confused with the Green Zone in downtown Baghdad, Iraq. Once the US military was in the region a similar recognition of severe injury pattern with associated complications was recognized. A US Army task force was established to summarize and analyze information to develop recommendations of care.⁵ At the same time, the infectious disease and surgical community noted increased rates of mold infections in these patients.⁶

In order to address the problem, numerous parallel programs were developed, including defining the problem, developing equipment to address the injury pattern, modification of TTPs to avoid the injury, and clinical practice guidelines to standardize care.

DEFINING THE PROBLEM

Once the risk was identified to be fundamentally due to large blast injuries associated with dismounted operations in southwest Afghanistan causing major limb amputations and perineal injuries, the next goal was to further stratify the patients to develop diagnostic and treatment protocols to minimize excess morbidity and mortality. Data collected from the DoDTR and ID Module was able to define regions of Afghanistan at highest risk, including case control analysis with 10-digit coordinates linked with geographic information system to identify other regions that were at potential risk if similar care and injury patterns developed.⁷ The overall evaluation allowed for the identification of risks for infections and poor outcomes.⁸⁻¹² Key characteristics included type of mold, region of the country, presence of ongoing necrotic tissue, blast injury, dismounted at time of injury, above the knee amputation, and large-volume packed red blood cell (greater than 20 units) transfusion within the first 24 hours. All of this information was able to assist in the development of equipment, TTPs, and guidelines to address the issue.

EQUIPMENT

Implementation and modification of body armor has greatly affected casualty outcomes. As such, a similar program was developed for this new injury pattern. The British led the way developing a 3 Tier system. Tier 1, issued in 2010, included layered synthetic silk cycling shorts that were thicker than previous issued cycling short-type underwear with some antimicrobial activity. Tier 2 was an over garment diaper appearing device with some ballistic protection that covered the perineal region to be worn with Tier 1. It was issued in February 2011 to all British troops to wear when operating outside the wire to apply in moderate IED threats. Tier

3 was issued in November 2011 with over-trousers that are ¾ length extending from the Tier 2 device to above the knee to be combined with Tier 1 and 2 worn mainly by the point men operating the metal detector. After November 1, 2010, the British military assessed adherence with overall 81% wearing any combination of Tier 1/2/3 when injured. They found that 78% were wearing Tier 1, 66% were wearing Tier 2, 6% were wearing Tier 3. Overall, 10% were not wearing pelvic protection with 12% injured in the first 2 months of Tier 1 issue; 71% were within the base not required to wear pelvic protection; and 16% were outside the wire. No documentation was available for 9% of casualties.

Genitourinary injury rate based upon Tier of protection at Bastion, Afghanistan between April 2, 2011 and September 30, 2011.		
Level of Tier Protection	High Lower Extremity Amputation with Genitourinary Injury n=45	Low Lower Extremity Amputation with Genitourinary Injury n=31
Tier 1 and 2	17%	0%
Tier 1 only	56%	25%
None	68%	21%
Unknown (n=11)	----	-----

As US Marines moved into the area, there was an opportunity to compare the British to US Marine equipment as the British mostly used Tier 1 and 2 while the Marines had only Tier 1. The information was collected from trauma logs from Bastion, Afghanistan, between April 1 and September 30, 2011. Overall, there were 45 US and British casualties in a high amputation group with unilateral or bilateral at or above the knee traumatic amputations, plus several with unilateral below knee or above ankle amputation. A comparison group of low amputations included 31 US or British casualties with unilateral or bilateral below knee or above ankle amputations, but no through the knee or above the knee amputations. There were 59 US and 17 British casualties (N=76) with decreased rates of genitourinary injuries of those wearing more protective equipment as shown in the Table. Ongoing analysis is required to continue to validate utility of this Tiered system, but the DoDTR does not collect this information and limited data from autopsy findings are released.

TACTICS, TECHNIQUES, AND PROCEDURES

There was a recognition from the line that the IEDs associated with dismounted blast injuries were placed along major valley paths with vegetation and waterways. However, the trigger mechanism was often present up in the rocky edges along the valley walls and was frequently human controlled to avoid indiscriminate injuring of animals or local personnel. Given this recognition, there was a switch to moving US military personnel away from

CHANGES IN EQUIPMENT AND TECHNIQUES/TACTICS/PROCEDURES THAT IMPACTED CARE AND OUTCOMES

the valley paths with vegetation and waterways to operate along the valley and rocky environment. Although there is no available data regarding implementation of this change or direct evidence of decreased injuries with its implementation, it does highlight that close communication of medical findings to the line allows a collaborative, multidisciplinary approach to address the problem using each group's unique perspective and skill set.

CLINICAL PRACTICE GUIDELINES

A number of standard clinical approaches were developed to ensure optimal delivery and standardization of care. A 2011 meeting to develop Combat-related Injury Practice Guidelines for Extremity Care identified fungal infections as a major gap with regards to information and care.¹³ After this meeting, Landstuhl Regional Medical Center established a standard approach to screening for invasive mold infection resulting in an ability to assess the utility of this clinical change in standard practice.¹⁴ There were 44 patients available for analysis pre-protocol and 30 postprotocol. Although there was less angioinvasive cases, fewer days to invasive mold infection diagnosis, fewer days to initiating antifungal therapy, and more patients receiving antifungal therapy after implementation of the protocol change, there were no changes in hospital days, ICU duration stay, operating room visits, high level amputations, or deaths. As such, there is likely more specific information required to clearly identify at risk patients, which likely includes host parameters and wound parameters such as ongoing necrotic tissue.

Infectious disease, orthopaedic surgeons, and trauma surgeons collaborated to develop a standard clinical practice guideline to address risk stratification of patients and management plans in and out of the combat zone.¹⁵ The development of the CPG demonstrates the value of a trauma system involved in combat casualty care from point of injury to return to the United States. During the weekly Thursday Theater Combat Casualty Care conference, colleagues at Walter Reed National Military Medical Center reported on casualties with progressively invasive fungal infections. This feedback to theater prompted a series of teleconferences moderated by the Joint Theater Trauma System Director. These teleconferences linked surgeons in theater, surgeons at Landstuhl Regional Medical Center, surgeons at Walter Reed National Military Medical Center, orthopaedic surgeons, and infectious disease specialists. Data from the Trauma Infectious Disease Outcomes Study group was reviewed for trends. From this collaboration, the Management of Suspected Invasive Fungal Infection CPG was formed. The trauma system demonstrated value in this circumstance as (1) a means to sense an evolving clinical issue, (2) enhancing communication by linking

subject matter experts of several disciplines and several locations, (3) reviewing data, (4) developing a clinical practice guideline, and (5) providing feedback to care providers along the continuum during weekly Thursday Theater Combat Casualty Care conferences. Most of these recommendations predated any of the publications that supported the initial conclusions that led to the document. These guidelines allowed for defining the problem, evaluating and treating the patient, and establishing a built in performance improvement monitoring process including standard notes and care. Although the clinical practice guidelines were implemented, the drastic changes in injury rates prevented any adequate powered analysis of the effect of the clinical practice guideline implementation to be undertaken.

Other research endeavors undertaken after recognizing the challenges was determining the ideal therapy for injuries, including agents such as Dakins solution or novel therapies such as tea tree oil.^{16,17} Although therapy recommendations for modifying Dakins solution to lower concentration were recommended in the guidelines, outcomes studies with adequate power were not possible. These studies should be conducted to validate that clinical changes affect outcomes similar to the lack of outcome changes associated with changing the diagnostic approach. It is important to notice that these studies were developed and carried out in military treatment facilities (MTFs) and not within the Medical Research and Materiel Command (MRMC) research programs. This reflects the ability of astute clinicians to recognize the problem and link to an answer. Overall, better collaboration with research commands is a priority as some research programs were reluctant to shift away from standard research focus areas.

WAY FORWARD

In order to continue to make advances for the next war, key issues within Doctrine, Organization, Training, Materiel, Leadership and education, Personnel, Facilities Policy (DOTMLPF-P) must occur to advance clinical care:

1. Maintaining the DoDTR with an ID Module is required as the ID module took 8 years from the onset of the war to become fully running in 2009, and a number of years after that for data analysis and publication of findings. This program needs to be written into Doctrine with clearly defined Organizational responsibility to monitor, assess, develop, deliver and then collect data based upon any changes to validate improvement. These validated improvements then are further codified into the appropriate section of DOTMLPF-P.

2. Vital to decreasing traumatic injuries and infections is avoidance of the injury in the first place. Key equipment is vital to this change and continue assessments of lessons learned through autopsy analysis of equipment and the DoDTR are required to transition to equipment studies, whether it be a tourniquet, eye covering, uniform, or vehicle. Once the equipment is placed into a system to fund, then training is required with incorporation across the Army as a whole, meaning not only the medical community.
3. Experts in the full spectrum of care from point of injury to rehabilitative specialty care are vital. The recognition of invasive fungal infection complication was detected in level V care facilities by clinically experienced subspecialists. However, it is incumbent that a pathway for communication throughout the organization be established as these lessons were not known or even managed in the dedicated research lanes such as MRMC. This requires better leadership links among casualty care across the full spectrum of operations, research, and clinical communities. General officer level responsibility for combat-casualty care within the AMEDD or at a joint assignment that links FORSCOM to MEDCOM and within MEDCOM MRMC to MTFs should be considered.
4. Establish the Joint Trauma System as the lead agency for trauma in the Department of Defense with authority to establish and assure best-practice trauma care guidelines to the Director of Defense Health Agency, the 3 services, and the combatant commanders.¹⁸
5. Ficke JR, Eastridge BJ, Butler FK, et al. Dismounted complex blast injury report of the army dismounted complex blast injury task force. *J Trauma Acute Care Surg.* 2012;73:S520-S532.
6. Warkentien T, Rodriguez C, Lloyd B, et al, for the IDCRP TIDOS group. Invasive mold infections following combat-related injuries. *Clin Infect Dis.* 2012;55:1441-1449.
7. Tribble DR, Rodriguez CJ, Weintrob AC, Shaikh F, Aggarwal D, Carson ML, Murray CK, Masuoka P, and IDCRP TIDOS. Environmental factors related to fungal wound contamination following combat trauma in Afghanistan (2009-2011). *Emerg Infect Dis.* 2015;21:1750-1760.
8. Rodriguez CJ, Weintrob AC, Shah S, et al, and IDCRP TIDOS Group. Risk factors associated with invasive fungal infections in combat trauma. *Surg Infect.* 2014;15:521-526.
9. Rodriguez C, Weintrob AC, Dunne JR, et al, and IDCRP TIDOS Investigative Team. Clinical relevance of mold culture positivity with and without recurrent wound necrosis following combat-related injuries. *J Trauma Acute Care Surg.* 2014;77:769-773.
10. Weintrob AC, Weisboror AB, Dunne JR, et al, and IDCRP TIDOS. Combat trauma-associated invasive fungal wound infections: epidemiology and clinical classification. *Epidemiol Infect.* 2015;143:214-224.
11. Warkentien TE, Shaikh F, Weintrob AC, et al, and IDCRP TIDOS Study Group. Impact of mucorales and other invasive molds on clinical outcomes of polymicrobial traumatic wound infections. *J Clin Microbiol.* 2015;53:2262-2270.
12. Lewandowski LR, Weintrob AC, Tribble DR, et al, and the IDCRP TIDOS Study Group. Early complications and outcomes in combat injury related invasive fungal wound infections: a case-control analysis. *J Orthop Trauma.* 2015 (Epub ahead of publication).
13. Murray CK, Obremskey WT, Hsu JR, et al, and the Prevention of Combat-related Infectious Guidelines Panel. Prevention of infections associated with combat-related extremity injuries. *J Trauma Acute Care Surg.* 2011;71:S235-S257.
14. Lloyd B, Weintrob AC, Rodriguez C, et al, and the IDCRP TIDOS Investigative Team. Effect of early screening for invasive fungal infections in US Service Members with explosive blast injuries. *Surg Infect.* 2014;15:619-626.
15. Treatment of suspected invasive fungal infection in war wounds [internet]. Joint Theater Trauma System Clinical Practice Guidelines. November 2012. Available at: http://www.usaisr.amedd.army.mil/cpgs/Invasive_Fungal_Infection_in_War_Wounds_1_Nov_12.pdf. Accessed October 9, 2015.

REFERENCES

1. Blyth DM, Yun HC, Tribble DR, Murray CK. Lessons of war: combat-related injury infections during the Vietnam War and Operation Iraqi and Enduring Freedom. *J Trauma Acute Care Surg.* 2015;79:S227-S235.
2. Kotwal RS, Howard JT, Oman JE, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg.* 2015;DOI: 10.1001/jamasurg.2015.3014.
3. Tribble DR, Conger NG, Fraser S, et al. Infection-associated clinical outcomes in hospitalized medical evacuees following traumatic injury- Trauma Infectious Disease Outcome Study (TIDOS). *J Trauma Acute Care Surg.* 2011;71:S33-S42.
4. Sharma DM, Webster CE, Kirkman-Brown J, Mossadegh, Whitbread T, on behalf of the Genitourinary Working Group (Trauma). *J Royal Army Medical Corps.* 2013;159Suppl:i1-i3.

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THAT IMPACTED CARE AND OUTCOMES

16. Homeyer DC, Sanchez CJ, Mende K, Beckius ML, Murray CK, Wenke JC, Akers KS. In vitro activity of *Melaleuca alternifolia* (tea tree) oil on filamentous fungi and toxicity to human cells. *Med Mycol.* 2015;53(3):285-294.
17. Barsoumian A, Sanchez CJ, Mende K, et al. In vitro toxicity and activity of Dakin's solution, mafenide acetate, and amphotericin B on filamentous fungi and human cells. *J Orthop Trauma.* 2013;27(8):428-436.
18. Combat Trauma Lessons Learned from Military Operations 2001-2013 [internet]. Defense Health Board Reports. Available at: <http://www.health.mil/About-MHS/Other-MHS-Organizations/Defense-Health-Board/Reports>. Accessed March 9, 2015.

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Battlefield Tourniquets: Lessons Learned in Moving Current Care Toward Best Care in an Army Medical Department at War

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Michael A. Dubick, PhD

ABSTRACT

Bleeding prevention and control by tourniquet use by out-of-hospital caregivers is a major breakthrough in military medicine of current wars. The present review documents developments in tourniquet practices since 2001 among the US military services for aid in improving doctrine, policy, and especially care in wars to come. Tourniquets are an adjunct for resuscitation in self-care and buddy aid and today are issued to all military servicepersons who deploy into a combat zone. In the US Army, virtually every Soldier is trained in first aid tourniquet use; since 2009 they are instructed early and often to use them early and often. Despite substantial knowledge gains among the services in tourniquet use and resulting improvements in casualty survival, current evidence shows persistent difficulties in achieving best care with tourniquet use for individual trauma patients. Nevertheless, contemporary tourniquet use incorporates key lessons learned over the last 14 years of war that include: (1) tourniquet use reliably stops bleeding from limb wounds and prevents mortality in prehospital settings; and (2) brief tourniquet use appears to be safe. These 2 lessons have become so evident that civilian emergency medical systems have begun using them, albeit unevenly. Collection and interpretation of data of casualties with tourniquet use have showed that such intervention has lifesaving benefit through 2 mechanisms: control of both ongoing hemorrhage and shock severity. The next generation of interventions in bleeding control involves developing the skill sets, education, and standards of tourniquet users which may improve hemorrhage control in wars to come.

Tourniquets today have come far from where they were on September 11, 2001. When war came to the United States on 9-11, tourniquets were a means of last resort in bleeding control. Today, tourniquet use is a means of first aid. The scientific evolution of tourniquets among the US military services since 9-11 has had one main finding: tourniquet use provides a significant survival benefit.^{1,5} However, little is known about that benefit: what is its size; who receives that benefit, and does it apply to both military and civilians?⁶ Other gaps include how to optimize performance of tourniquet users.³ A reminder of our current need to know such things may aid ongoing efforts of key leaders to maintain a scholarly focus within the US Army Medical Department so that it does not drift. “No drift” is a mantra of stewards of combat casualty care research so that the military goes to the next war without having to relearn lessons of past wars, i.e., without the need to improve caregiving to reach levels of the last war.⁴

In an effort to maintain a scholarly focus on improving first aid, the present update gives a basic understanding of the recent scientific evolution of tourniquets in the US military. The present review documents such lessons not only to improve doctrine and policy today, but

also—and especially—to prevent such drift and thereby improve care in future wars. Furthermore, the lessons learned by the military may guide improvements in civilian first aid.

UPDATE ON CURRENT USE OF TOURNIQUETS IN THE US ARMY

Tourniquet use in the military services today incorporates 4 key lessons learned over the last 14 years of war. The first lesson about tourniquet use the military learned in the current war was that we should not forget to focus on what we need to know; that is to say, what is not already in the lesson plans of medics. Although we have learned much recently, such as if surviving casualty percentages are compared between those with first tourniquet use after shock onset and those who are not in shock at first use, the fact remains that shock onset is associated with more mortality—as much as 80% to 92%.^{2,7} However, such a difference is not a treatment effect of tourniquets, it is a difference in shock effect.⁶ Such a need to know more about first aid is a still a well-established knowledge gap; tourniquet use provides a ready example of such gaps.^{5,6} Some such gaps are discovered by trying to answer questions such as, what is the effect size of tourniquet treatment?⁵

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A military survey reported in 2015 that tourniquet use was associated with worse shock and more transfusion requirements among hospital-admitted casualties, yet those who received tourniquets had survival rates similar to those of comparable, transfused casualties who did not receive tourniquets.^{5,6} Does effectiveness vary by clinical setting (use out-of-hospital vs emergency department)? Surveys of military casualties have shown that first use of tourniquets in such settings is associated with improved survival if use is earlier; specifically, survival has been associated with prehospital application (89% vs 78% hospital, $P < .01$) and application before the onset of shock (96% vs 4% after).^{2,7} But such surveys began at the emergency department, not at the time of indication which is a better, albeit harder, way of surveying the need for intervention.^{2,6,7} Does effectiveness vary by condition of the casualty (degree of shock or injury severity)?^{5,6} An evaluation of tourniquet use for patients treated at forward surgical (Role 2) facilities revealed an association with improved survival and reduced shock index on arrival; a 20% reduction of mortality was associated with each increase of 0.2 unit of shock index (odds ratio [OR], 1.27; 95% confidence interval [CI], 1.12-1.42) in tourniquet use vs nonuse (OR, 1.46; 95% CI, 1.37-1.56).⁸ However, in this study the time-course of individuals casualties was not tracked for shock control as the data were not paired in 2 times for an individual; such cohort data are more like epidemiology of large groups rather than treatment of individual patients—the difference between public health of populations and health care of individuals.

What should first aid instructors teach about how and when to use tourniquets, for example, at a marathon bombing or at a shooting in a movie theater? Such questions are basic to how and when caregiving is needed.^{5,6} Data gathered regarding improvised tourniquets has advanced rapidly since 2013, and improvised strap-and-windlass tourniquets have been shown to be more effective than those with no windlass, as a windlass allowed the user to gain mechanical advantage. However, improvised strap-and-windlass tourniquets fail to control hemorrhage often (ie, 32% of tests), even in a laboratory setting.^{9,10} In a second laboratory study of improvised tourniquets, the commercial Combat Application Tourniquet (CAT) was a control for the US Army improvised tourniquet and a bandana-windlass tourniquet; CAT performed fastest ($P < .0001$, both), but both improvised techniques were not statistically different from each other. All time-of-application results in the commercial group were less than the minimums of either improvised group.¹¹ In a third laboratory study of improvised windlasses, effectiveness, windlass turn numbers, time to stop bleeding, the number of windlasses, and

the under-tourniquet pressure were associated inversely with breakage.¹² The windlass type was associated with breakage; only chopsticks were without breakage at 2 windlasses. Of those windlass types that broke, 21% were chopsticks, 26% were pencils, and 53% were craft sticks; such data showed differential value of various items used together as one working windlass.¹² In a fourth laboratory study of a standard issue military tourniquet, tourniquet effectiveness rates were uniformly 100% irrespective of whether the windlass position was medial, lateral, anterior, or posterior.¹³ Presently, much other information is lacking about what first aid instructors should teach about how and when to use tourniquets, and a focus on user development is needed if we are to optimize user performance.

The second lesson the military learned about tourniquet use was that its use provided a survival benefit while safety was also provided.^{1,2} A tourniquet survey began in Baghdad was made in 3 sequential parts and observed casualties with tourniquet indications.¹⁴ Altogether, the survey included 727 patients with 1,212 tourniquets used on 952 limbs.^{2,7,10,14-17} This large survey was useful by dispelling theories that were wrong and confirming theories that were right.^{2,17} The performance improvement aspect of the large survey was emphasized in the third time period surveyed which showed increased usage of tourniquets within the US military trauma system in Baghdad in 2007 (Figure 1).¹⁷ This survey over 466 days showed that (1) the appropriate wound indication rose from 96% to 99%, (2) first usage before shock onset for individual casualties rose from 96% to 99%, and (3) the prehospital (first use before hospital) usage rose from 84% to 97%.¹⁷ All of these changes were significant. A newly refined concept of bleeding control by tourniquet use emerged that indicated the patient's status regarding hemorrhagic shock at the time of first tourniquet use was the main determinant of survival. If shock onset had not occurred, tourniquet use was associated with high survival rates as documented by both a higher proportion of surviving patients and a longer duration of patient survival.² Much like emergency room thoracotomy, shock onset (as indicated by loss of a palpable peripheral pulse) before tourniquet use was associated with low survival rates.² Furthermore, minor morbidity during tourniquet use was empirically confirmed as few, temporary, and incomplete.¹⁵ Such a refined understanding led to renewed efforts to use tourniquets early and often, and tourniquet trends showed good results such as improving survival (decreasing case fatality rates of all-causes) despite increasing injury severity.^{5,6,8,15,17}

The third lesson about tourniquet use that the military learned in the current war was that the users' concepts

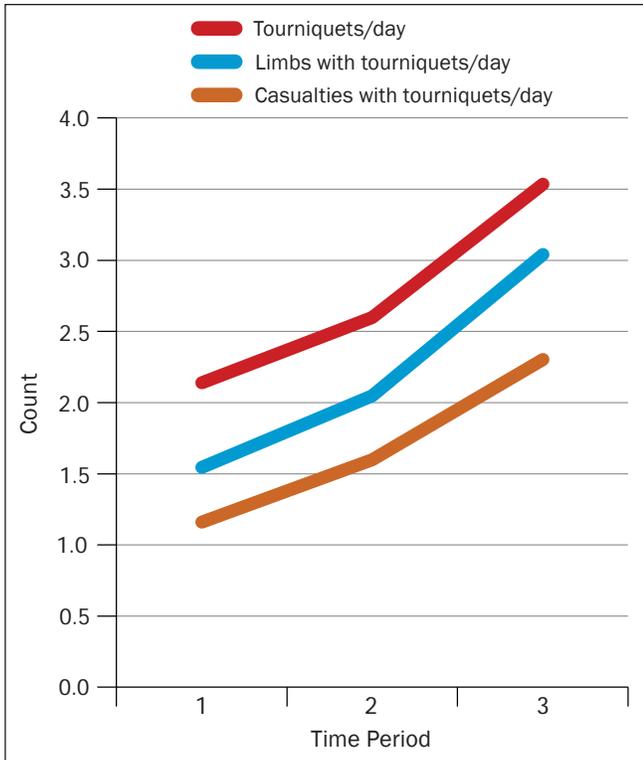


Figure 1. Improvement in use of tourniquets by time period in a Baghdad combat support hospital during 2006-2007. The time span is separated into 3 distinct, sequential periods: 1-Precondition; 2-Preparation; 3-Execution of the Surge. Data source: Kragh et al.¹⁷

of tourniquets changed. Early in the war, a tourniquet was a device, a materiel item issued within an individual's first aid kit. Since tourniquets were devices made of materials familiar to Soldiers like nylon webbing and a metal rod, early in the war Soldiers innately thought of them as a mechanical means of compressing limbs and underlying blood flow to control bleeding from wounds. Such mechanistic thinking was easy to teach and learn, as illustrated in Figure 2, and there was little action needed to develop user training (eg, learning curves, skill decay measurement, or differentiating user skillsets by experience level). Situational concerns were more apparent at the beginning of the war. For example, strategies concerning tourniquet use might change in an environment-dependent manner: Care Under Fire (tourniquets could be tried first) versus Tactical Field Care (tourniquets were to be tried last). Tourniquets applied in the field were often found later to be relatively loose by physicians, and the looseness problem was thought to be caused by the tourniquet user applying them too loose. However, the problem was eventually understood and explained better through research from Iowa.^{19,20} Difficulty in achieving arterial compression was explained by civilian researchers who showed that persons with tourniquets applied changed over time during tourniquet use; the individual's limb changed.^{19,20} A person who self-applied their tourniquet to their arm, for example, soon relaxed their arm muscles which altered the

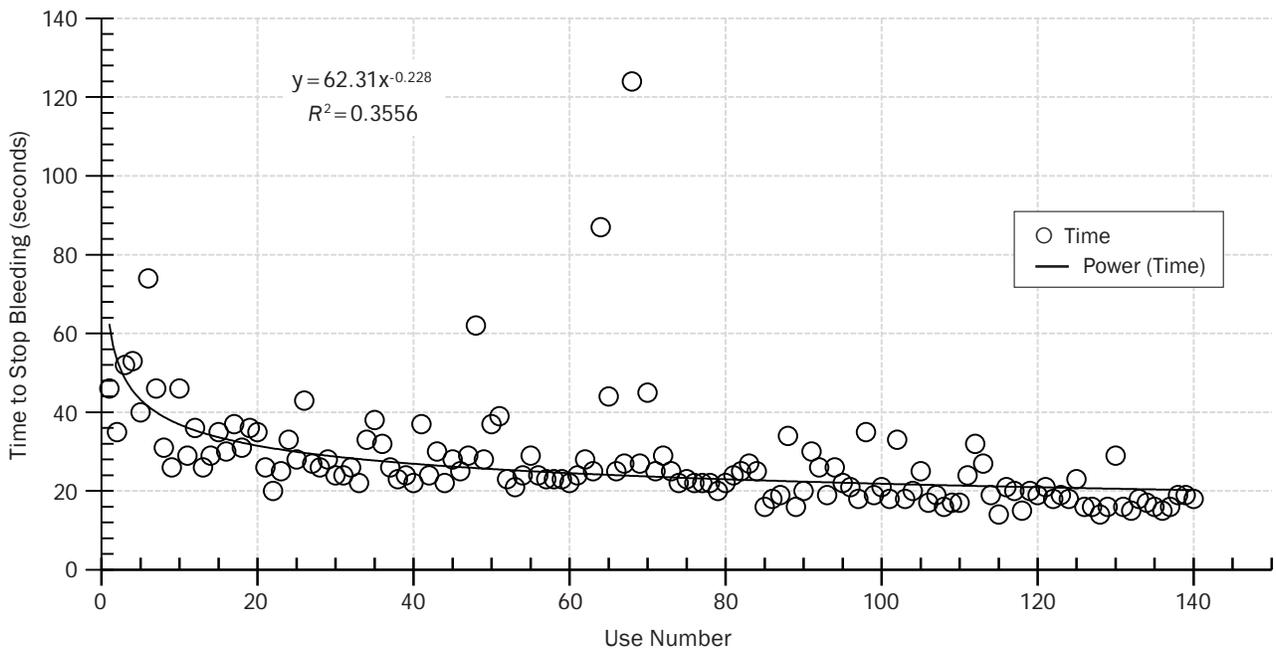


Figure 2. Learning curve for a user of a first aid tourniquet (on a manikin). For this subject, the data indicates that the user learned to achieve better bleeding control by becoming faster. The variance tended to decrease, but the maximum variance in use-to-use was in use number 68, surprisingly late and after almost half of the experience. This chart was generated for this article using data from Davinson et al.¹⁸

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tourniquet effectiveness from arterial to venous control within minutes.^{19,20} Further research showed that there was variance in applied pressures under tourniquets even of the same model applied by the same person.^{19,20} More research showed that compression of the limb changed the underlying limb itself by extruding blood from all vessels and lymph from the lymphatic system.¹⁹⁻²¹ Such fluid extrusion altered effectiveness of the tourniquet as its pressure applied to the skin dropped within minutes, which in turn allowed arterial flow to recur while venous flow remained blocked; a bad situation—a venous tourniquet. Moreover, the blood and lymph responses differed over time; the blood effects were faster and the lymph effect was slower.¹⁹⁻²¹ From such science, refinements were subsequently made to caregiving guidelines to underscore the importance and to increase the frequency of users reassessing casualties with tourniquets.²² Given such subtle science, a refined understanding occurred to change the tourniquet concept from mechanistic to probabilistic. That is to say, tourniquet use was not a simple, mechanistic, yes-no intervention. Rather, each use had a probability of success that could be partial, change over time, or be altered by the specific situation. The mechanistic concept changed to a tetrad concept wherein the 4 interrelated parts of the tetrad are a user, a patient, an intervention, and a situation, as shown by Figure 3. This new concept is dynamic as all elements can change, and such change means that empiric results are probabilistic and not purely mechanistic; empiric outcomes of tourniquet use indicate that the probability of better outcomes is associated with improvements in care delivered. In another example of improved caregiving from the large, 3-part Baghdad survey, the rate of limbs with only one tourniquet used increased from 66% to 74% to 89%; while tourniquet models themselves did not change, and while injury numbers and severity increased, improvements appeared to come from users as use, experience, and efficiency improved.¹⁰ Such new knowledge involving best tourniquet practices is continuously and incrementally added. Given battlefield experience over a decade, knowledge of wear and tear of tourniquets has increased in part through scientific inquiries.²³⁻²⁶ For one example, in a study of heat exposure, prolonged dry heat was not associated with change in tourniquet effectiveness rates ($P=.32$); when adjusted for the effects of user and model, the comparisons of time to effectiveness and total blood loss were statistically significant ($P<.0001$), but the comparison of pressure was not ($P=.0613$) as user effects appeared to affect outcomes while exposure did not.¹⁸ The military changed its concept of the tourniquet to become a concept of dynamic interrelation among users-situations-patients-tourniquets.

What the military teaches Soldiers in tourniquet application is substantial in breadth and occasionally in depth. In an example of breadth, all new Army recruits learn tourniquets upon initial entry training, receive further detailed training during subsequent advanced individual training in a combat lifesaver course, and get predeployment refresher training. (and data to support why when available) gaps that remain. Another example of breadth: medics receive training in greater specificity for their more advanced skillset than other Soldiers, and they often are taught about troubleshooting difficult cases and converting tourniquets to pressure dressings. Specific information about what Soldiers are taught about tourniquet application is included in the Combat Lifesaver course.²⁷ Specific information that military medics are taught about tourniquet application is presented in Figure 4.

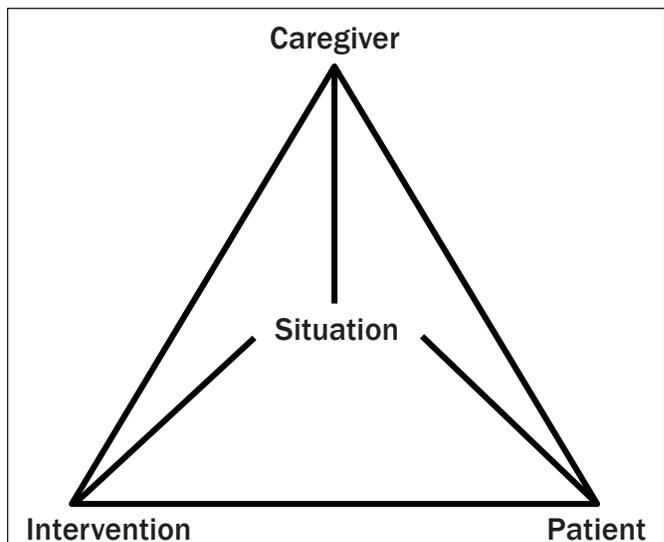


Figure 3. A new schema of tourniquet science developed recently includes the dynamic interaction among components of a tetrad that include a patient, a caregiver, an intervention, and a situation, represented schematically as a tetrad. Each item in the tetrad can change. The caregiver may also be the patient in self-applied tourniquet use. Each item is interrelated with the others. For example, if a casualty (patient) is wounded in a limb in combat, a Soldier (caregiver) provides first aid with tourniquet use (intervention) during Care Under Fire (situation). Soon after the end of active combat, the situation changes to Tactical Field Care (a new situation) wherein Soldiers are taught to convert the tourniquet use to use of a pressure dressing. The schema alters the perception of the challenges for looking just at the device (the tourniquet) to invite looking at each item and each interrelation. The tourniquet is a tool, and its use is the intervention; deemphasizing other items makes the problem simpler than reality, an over-simplification which generates unintended problems such as under-emphasizing patient reassessment. The patient changes because of the intervention. The patient also changes over time and requires rechecking if the limb under the tourniquet gets smaller from applied pressure.

The fourth lesson the military learned about tourniquet use in the current war was that today, in developing the way ahead for military medicine, civilians may also improve their use of tourniquets. Such implementation gaps also apply to civilian first aid situations wherein similar risks occur (eg, external hemorrhage associated with penetrating trauma).^{4,22} Such application led civilian medical authorities to reverse course and recommend tourniquet use.²⁸⁻³⁰ An increasing number of clinical studies from civilian settings have been published since 2014 indicating that several of the military findings about tourniquet use are supported by comparable civilian findings such as lifesaving benefit and safety of use.³¹⁻³⁷ However, civilian adoption of tourniquet use is currently uneven.³⁸ Defense research in out-of-hospital use of tourniquets paved the way for civilian use, and both military and civilian investigators are considering extension of other interventions to control hemorrhage, such as prehospital use of pelvic binders. On the road from current care toward best care, the lessons that the military learned about what is necessary for a large trauma system to work well is also improving civilian caregiving.

CURRENT STATUS OF TOURNIQUET USE
IN ALL US MILITARY SERVICES IN 2015

As a result of one of the longest wars in US history in which combat still continues, the military is keenly aware of existing knowledge gaps. Another important gap relevant to the military services presently being addressed by ongoing research is junctional hemorrhage, ie, bleeding from wounds at the torso-appendage junctions where limb tourniquets cannot fit.³⁹⁻⁴² Presently, there are few clinical trials, junctional case reports, or case series of hemostatic dressing use, but there are some laboratory and preclinical studies.⁴³⁻⁴⁷ Additionally, the hydraulic or mechanical effects of wound packing in bleeding control are becoming better understood.^{48,49} The principles of controlling hemorrhage early by mechanical methods appear to apply to all portions of the extremities: the limbs where limb tourniquets fit and junctional parts of extremities where junctional tourniquets fit. Furthermore, tourniquets have been proposed in prolonged field care for mitigation of reperfusion after limb crush syndrome, although limited experience is available for decision-making.^{10,50-52} The topics of junctional bleeding and crush syndrome require further research to provide evidence of effectiveness and safety.

Tourniquets in 2015 are issued to all military service personnel who deploy into a combat zone. In the US Army, virtually every Soldier is trained in tourniquet use—early and often. For example, since 2009 all recruits (new enlisted Soldiers) irrespective of specialty

- (1) To maintain firepower supremacy, only extremity bleeding should warrant any intervention during Care Under Fire.
 - (a) Casualty blood sweeps are not recommended during this phase of care. The assessment takes a considerable amount of time to complete and leaves the care giver vulnerable to the enemy.
 - (b) Visual inspection is not necessary until both the care provider and the casualty are behind cover.
 - (c) When approaching the casualty, if blood is apparent on the shirt sleeve or the pant leg, that is all the proof necessary to warrant application of a tourniquet.
- (2) When the tactical situation dictates, no intervention should be employed unless and until:
 - (a) The unit can afford to have the provider drop out of the fire fight long enough to intervene.
 - (b) Efforts to direct the self-aid/buddy aid have failed.
- (3) Tourniquets are the only recommended treatment for extremity hemorrhage during this phase. (Remember: 30 seconds on the “X” is 25 seconds too many. Even if it take only a few seconds to apply a tourniquet, that is enough time for the enemy to take aim and fire on both you and the casualty.)
 - (a) Intervention should take place under suitable cover or concealment. This may require that you initially move the casualty before placing a tourniquet.
 - (b) The intervention should be tactically feasible as to avoid a circumstance where the care giver is an additional casualty.
 - (c) For obvious life threatening extremity hemorrhage.
 - 1) You may not really know if hemorrhage is life threatening until Tactical Field Care phase when the wound can be exposed and evaluated.
 - 2) The suspicion of life threatening hemorrhage is the only required criteria during Care under Fire.
- (4) All tourniquets placed during Care Under Fire should be Hasty Tourniquets.
 - (a) Place over the clothing.
 - (b) As high on the extremity as possible (without capturing the shoulder or the buttock).
 - 1) Rarely are combat wounds clean incisions perpendicular through the extremity.
 - 2) This placement is preferred during Care under Fire because of the inability to properly expose and assess the wound.
 - 3) High application ensures the tourniquet is placed completely above any possible damaged/injured tissue.
 - (c) As tightly as possible (due to the limitations during this phase of care, pulse checks are not required).
- (5) Hasty Tourniquets should be converted to an alternative form of hemorrhage control prior to evacuation, typically during the Tactical Field Care Phase.

Figure 4. Excerpt from student handout for US Army Medic: Tourniquet Use During Care under Fire.

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have been trained in tourniquet use in Basic Combat Training (also known as Initial Entry Training) that includes a Combat Lifesaver Course in first aid skills. Soon thereafter in Advanced Individual Training, more tourniquet training is again provided. Further training may be given when Soldiers are assigned to their units, and refresher training occurs before deployments. Such a systematic and long-standing program has changed the US Army's first-aid culture. Before 2009, tourniquets were new, a new way of doing things; after 2009, they were old. Prior to 2009, such a culture change was made in miniature by individual units like the 75th Ranger Regiment and Special Operations Forces. After their success, leaders of other organizations used it as a template for expanding this critical knowledge to all Soldiers.²

NEXT GENERATION OF BLEEDING CONTROL
INTERVENTIONS

Current evidence shows that user development is important to best performance in bleeding control interventions.^{18,53,54} Moreover, an emphasis on the quality of training should be recognized, understood by key leaders, planned for in military units, and made a priority. Among all areas associated with improvement of tourniquet use (ie, Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities [DOTMLPF]), training is today the quintessential item to be addressed for tourniquet use: optimal user development is the most likely of all factors to improve outcomes. The path from current care toward best care is challenging; may we journey with knowledge, hope, and determination.

REFERENCES

1. Beekley AC, Sebesta JA, Blackbourne LH, et al, for the Combat Support Hospital Research Group. Prehospital tourniquet use in Operation Iraqi Freedom: effect on hemorrhage control and outcomes. *J Trauma*. 2008;64(suppl 2):S28-S37.
2. Kragh JF Jr, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, Holcomb JB. Survival with emergency tourniquet use to stop bleeding in major limb trauma. *Ann Surg*. 2009;249:1-7.
3. Markenson D, Ferguson JD, Chameides L, et al. Part 13: First aid: 2010 American Heart Association and American Red Cross International Consensus on First Aid Science With Treatment Recommendations. *Circulation*. 2010;122(16 suppl 2):S582-S605.
4. Rasmussen TE, Baer DG. No drift. *JAMA Surg*. 2014;149:221-222.
5. Kragh JF Jr, Nam JJ, Berry KA, et al. Transfusion for shock in US military war casualties with and without tourniquet use. *Ann Emerg Med*. 2015;65:290-296.
6. Kragh JF Jr, Aden JK III, Walters TJ, et al. In reply. *Ann Emerg Med*. 2015;66:340-341.
7. Kragh JF Jr, Littrel ML, Jones JA, Walters TJ, Baer DG, Wade CE, Holcomb JB. Battle casualty survival with emergency tourniquet use to stop limb bleeding. *J Emerg Med*. 2011;41:590-597.
8. Le TD, Kragh JF Jr, Gross KR, et al. Impact of tourniquet use on mortality and shock for patients arriving at U.S. Role 2 surgical facilities in Afghanistan. Poster presentation at: Military Health System Research Symposium; Fort Lauderdale, Florida; August 17-20, 2015.
9. Altamirano MP, Kragh JF Jr, Aden JK III, Dubick MA. Role of the windlass in improvised tourniquet use on a manikin hemorrhage model. *J Spec Oper Med*. 2015;15(2):42-46.
10. Kragh JF Jr, Walters TJ, Baer DG, Fox CJ, Wade CE, Salinas J, Holcomb JB. Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma*. 2008;64(suppl 2):S38-S49; discussion S-50.
11. Lyles WE III, Kragh JF Jr, Aden JK, Dubick MA. Testing tourniquet use in a manikin model: two improvised techniques. *J Spec Oper Med*. 2015;15(4):21-26.
12. Kragh JF Jr, Wallum TE, Aden JK III, Dubick MA, Baer DG. Which improvised tourniquet windlasses work well and which ones won't?. *Wilderness Environ Med*. 2015;26(3):401-405.
13. Kragh JF Jr, Wallum TE, Aden JK III, Dubick MA, Baer DG. Emergency tourniquet effectiveness in four positions on the proximal thigh. *J Spec Oper Med*. 2014;14(1):26-29.
14. Kragh JF Jr, Walters TJ, Westmoreland T, et al. Tragedy into drama: an American history of tourniquet use in the current war. *J Spec Oper Med*. 2013;13(3):5-25.
15. Kragh JF Jr, O'Neill ML, Walters TJ, et al. Minor morbidity with emergency tourniquet use to stop bleeding in severe limb trauma: research, history, and reconciling advocates and abolitionists. *Mil Med*. 2011;176:817-823.
16. Kragh JF, O'Neill ML, Beebe DF, Fox CJ, Beekley A, Cain J, Parsons D, Mabry R, Blackbourne L. Survey of the indications for use of emergency tourniquets. *J Spec Oper Med*. 2011;11(1):30-38.
17. Kragh JF, Beebe DF, O'Neill ML, Beekley AC, Dubick MA, Baer DG, Blackbourne LH. Performance improvement in emergency tourniquet use during the Baghdad surge. *Am J Emerg Med*. 2013;31:873-875.
18. Davinson J, Kragh JF Jr, Aden J III, DeLorenzo R, Dubick M. Laboratory testing of emergency tourniquets exposed to prolonged heat. *J Spec Oper Med*. 2015;15(1):34-38.

19. Slaven SE, Wall PL, Rinker JH, Halub ME, Hopkins JW, Sahr SM, Buising CM. Initial tourniquet pressure does not affect tourniquet arterial occlusion pressure. *J Spec Oper Med.* 2015;15(1):39-49.
20. Slaven SE, Gildemaster Y, Rometti M, Hopkins JW, Sahr SM, Buising CM, Wall PL. Pattern of pressure loss under strap tourniquets immediately following application. Poster presentation at: 2014 Special Operations Medical Association Scientific Assembly; December 8-11, 2014; Tampa, Florida.
21. Wall PL, Coughlin O, Rometti M, et al. Tourniquet pressures: strap width and tensioning system widths. *J Spec Oper Med.* 2014;14(1):19-29.
22. Shackelford SA, Butler FK Jr, Kragh JF Jr, Stevens RA, Kotwal RS, Mabry RL, Bailey JA. Optimizing the use of limb tourniquets in tactical combat casualty care: TCCC Guidelines Change 14-02. *J Spec Oper Med.* 2015;15(1):17-31.
23. Kragh JF Jr. Use of tourniquets and their effects on limb function in the modern combat environment. *Foot Ankle Clin.* 2010;15:23-40.
24. Childers R, Tolentino JC, Leasiolagi J, Wiley N, Liebhardt D, Barbabella S, Kragh JF Jr. Tourniquets exposed to the Afghanistan combat environment have decreased efficacy and increased breakage compared to unexposed tourniquets. *Mil Med.* 2011;176:1400-1403.
25. Kragh JF Jr, O'Neill ML, Walters TJ, et al. The military emergency tourniquet program's lessons learned with devices and designs. *Mil Med.* 2011;176:1144-1152.
26. Kragh JF Jr, Burrows S, Wasner C, et al. Analysis of recovered tourniquets from casualties of Operation Enduring Freedom and Operation New Dawn. *Mil Med.* 2013;178:806-810.
27. US Army. *Combat Lifesaver Course: Student Self Study Manual, Subcourse ISo871.* ed C. Fort Sam Houston, TX: US Army Medical Department Center & School; September 2013.
28. Fox N, Rajani RR, Bokhari F, et al. Evaluation and management of penetrating lower extremity arterial trauma: an Eastern Association for the Surgery of Trauma practice management guideline. *J Trauma Acute Care Surg.* 2012;73(5 suppl 4):S315-S320.
29. Bulger EM, Snyder D, Schoelles K, et al. An evidence-based prehospital guideline for external hemorrhage control: American College of Surgeons Committee on Trauma. *Prehosp Emerg Care.* 2014;18:163-173.
30. Jacobs LM Jr. Joint Committee to Create a National Policy to Enhance Survivability from Mass Casualty Shooting Events: Hartford Consensus II. *J Am Coll Surg.* 2014;218:476-478.
31. Passos E, Dingley B, Smith A, et al. Tourniquet use for peripheral vascular injuries in the civilian setting. *Injury.* 2014;45:573-577.
32. Zietlow JM, Zietlow SP, Morris DS, Berns KS, Jenkins DH. Prehospital use of hemostatic bandages and tourniquets: translation from military experience to implementation in civilian trauma care. *J Spec Oper Med.* 2015;15(2):48-53.
33. Ode G, Studnek J, Seymour R, Bosse MJ, Hsu JR. Emergency tourniquets for civilians: can military lessons in extremity hemorrhage be translated?. *J Trauma Acute Care Surg.* 2015;79:586-591.
34. Schroll R, Smith A, McSwain NE Jr, et al. A multi-institutional analysis of prehospital tourniquet use. *J Trauma Acute Care Surg.* 2015;79:10-14.
35. Inaba K, Siboni S, Resnick S, et al. Tourniquet use for civilian extremity trauma. *J Trauma Acute Care Surg.* 2015;79:232-237.
36. Meizoso JP, Valle EJ, Allen CJ, et al. Decreased mortality after prehospital interventions in severely injured trauma patients. *J Trauma Acute Care Surg.* 2015;79:227-231.
37. Alpert EA, Lipsky AM, Elie ND, Jaffe E. The contribution of on-call, volunteer first responders to mass-casualty terrorist attacks in Israel. *Am J Disaster Med.* 2014;10:35-39.
38. Haider AH, Piper LC, Zogg CK, et al. Military-to-civilian translation of battlefield innovations in operative trauma care. *Surgery.* 2015;158:1686-1695.
39. Tovmassian RV, Kragh JF Jr, Dubick MA, Baer DG, Blackbourne LH. Combat ready clamp medic technique. *J Spec Oper Med.* 2012;12(4):72-78.
40. Kragh JF Jr, Murphy C, Dubick MA, Baer DG, Johnson J, Blackbourne LH. New tourniquet device concepts for battlefield hemorrhage control. *US Army Med Dep J.* April-June 2011:38-48.
41. Kragh JF Jr, Mann-Salinas EA, Kotwal RS, et al. Laboratory assessment of out-of-hospital interventions to control junctional bleeding from the groin in a manikin model. *Am J Emerg Med.* 2013;31(8):1276-1278.
42. Kragh JF Jr, Parsons DL, Kotwal RS, et al. Testing of junctional tourniquets by military medics to control simulated groin hemorrhage. *J Spec Oper Med.* 2014;14(3):58-63.
43. Mann-Salinas EA, Kragh JF Jr, Dubick MA, Baer DG, Blackbourne LH. Assessment of users to control simulated junctional hemorrhage with the combat ready clamp (CRoC™). *Int J Burns Trauma.* 2013;3(1):49-54.
44. Kragh JF Jr, Dubick M, Aden J III, McKeague A, Rasmussen T, Baer D, Blackbourne L. U.S. military experience with junctional wounds in war from 2001 to 2010. *J Spec Oper Med.* 2013;13(4):76-84.

CHANGES IN EQUIPMENT AND TECHNIQUES/TACTICS/PROCEDURES
THAT IMPACTED CARE AND OUTCOMES

45. Kragh JF Jr, Johnson JE, Henkel CK, Dubick MA. Technique of axillary use of a combat ready clamp to stop junctional bleeding. *Am J Emerg Med.* 2013;31(8):1274-1276.
46. Johnson JE, Sims RK, Hamilton DJ, Kragh J. Safety and effectiveness evidence of SAM? Junctional tourniquet to control inguinal hemorrhage in a perfused cadaver model. *J Spec Oper Med.* 2014;14(2):21-25.
47. Klotz JK, Leo M, Anderson B, et al. First case report of SAM? Junctional tourniquet use in Afghanistan to control inguinal hemorrhage on the battlefield. *J Spec Oper Med.* 2014;14(2):1-5.
48. Kragh JF Jr, Steinbaugh J, Parsons DL, Mabry RL, Kheirabadi BS, Dubick MA. A manikin model for study of wound packing interventions to control out-of-hospital hemorrhage. *Am J Emerg Med.* 2014;32(9):1130-1131.
49. Kragh JF, Aden JK, Steinbaugh J, Bullard M, Dubick MA. Gauze vs XSTAT in wound packing for hemorrhage control. *Am J Emerg Med.* 2015;33(7):974-976.
50. Porter K, Greaves I. Crush injury and crush syndrome: a consensus statement: Keith Porter and Ian Greaves review the findings of a consensus meeting on crush injury and crush syndrome held in Birmingham on May 31 2001 and co-ordinated by the faculty of pre-hospital care of the Royal College of Surgeons of Edinburgh. *Emerg Nurse.* 2003;11:26-30.
51. Schwartz DS, Weisner Z, Badar J. Immediate lower extremity tourniquet application to delay onset of reperfusion injury after prolonged crush injury. *Prehosp Emerg Care.* 2015;19(4):544-547.
52. Kragh JF Jr, Baer DG, Walters TJ. Extended (16-hour) tourniquet application after combat wounds: a case report and review of the current literature. *J Orthop Trauma.* 2007;21:274-278.
53. Clumpner B, Polston R, Kragh JF Jr, et al. Single versus double routing of the band in the combat application tourniquet. *J Spec Oper Med.* 2013;13(1):34-41.
54. Polston RW, Clumpner BR, Kragh JF Jr, Jones JA, Dubick MA, Baer DG. No slackers in tourniquet use to stop bleeding. *J Spec Oper Med.* 2013;13(2):12-19.

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Special Operations Forces
Tactical Tourniquet



Combat Application Tourniquet

Lessons Learned for the Resuscitation of Traumatic Hemorrhagic Shock

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ABSTRACT

The lessons learned regarding the resuscitation of traumatic hemorrhagic shock are numerous and come from a better understanding of the epidemiology, pathophysiology, and experience in this population over 10-plus years of combat operations. We have now come to better understand that the greatest benefit in survival can come from improved treatment of hemorrhage in the prehospital phase of care. We have learned that there is an endogenous coagulopathy that occurs with severe traumatic injury secondary to oxygen debt and that classic resuscitation strategies for severe bleeding based on crystalloid or colloid solutions exacerbate coagulopathy and shock for those with life-threatening hemorrhage. We have relearned that a whole blood-based resuscitation strategy, or one that at least recapitulates the functionality of whole blood, may reduce death from hemorrhage and reduce the risks of excessive crystalloid administration which include acute lung injury, abdominal compartment syndrome, cerebral edema, and anasarca. Appreciation of the importance of shock and coagulopathy management underlies the emphasis on early hemostatic resuscitation. Most importantly, we have learned that there is still much more to understand regarding the epidemiology, pathophysiology, and the resuscitation strategies required to improve outcomes for casualties with hemorrhagic shock.

Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) in Afghanistan have proven to be crucibles of learning for combat casualty care. This brief review will summarize recent advances in our understanding of the epidemiology of combat trauma, the importance of shock and coagulopathy, the concept of damage control resuscitation, the limits of hypotensive resuscitation, the central role of blood products in hemostatic resuscitation, and the role of systemic hemostatic adjuncts.

EPIDEMIOLOGY

Recent evidence from the Iraq and Afghanistan conflicts indicates that 90% of combat deaths occur in the prehospital phase of care, and that 25% of these deaths are potentially preventable with existing medical technology. Significantly, 90% of medically preventable deaths occur due to hemorrhage.^{1,2} Although major advances in hemorrhage control have been made with the reintroduction of tourniquets, noncompressible hemorrhage remains a major challenge. There were 4,596 combat deaths in a 10-year period from 2001 to 2011, of which about 1,000 were due primarily to hemorrhage and were potentially preventable. Overall, when patients requiring massive transfusion during their initial resuscitations are considered, it is apparent that about 10% of combat wounded are at high risk of early exsanguination and require aggressive, early hemorrhage control

and blood-based resuscitation beginning in the prehospital phase of care to reduce morbidity and mortality.³

SHOCK AND COAGULOPATHY

On average, OIF/OEF patients requiring blood transfusion presented to combat support hospitals with an International Normalized Ratio (INR) of 1.5; nonsurvivors averaged an INR of 2.2 on admission.⁴ Oxygen debt due to ischemia during hemorrhagic shock causes organ dysfunction and ultimately death if not reversed with timely resuscitation. Shock causes endothelial dysfunction and this has been associated with the development of a primary or endogenous coagulopathy which includes activation of fibrinolysis. In addition, mechanisms such as autohemodilution from mobilization of interstitial fluid, catecholamine release, proinflammatory signaling, and other poorly understood pathways, such as the unique contribution of traumatic brain injury (TBI), contribute to this endogenous coagulopathy.^{5,6} Primary coagulopathy occurs early after injury and is more severe with increased amount of tissue injury. In early primary coagulopathy, thrombin generation is typically elevated compared to uninjured subjects; the degree to which thrombin is a limiting factor in hemostatic function for these patients is thus debatable.⁷ Over time, with resuscitation and ongoing bleeding, a secondary or exogenous coagulopathy occurs as a result of further dilutional and consumptive etiologies. Thrombin

generation can be reduced as a result of this secondary or exogenous coagulopathy.⁸ Since it is difficult to rapidly identify primary or secondary coagulopathy with current clinically available measures of hemostasis, goal-directed therapy is difficult to achieve. In principle, the rapid treatment and prevention of both shock and coagulopathy with early surgical control of bleeding and hemostatic resuscitation with blood products that deliver the functionality of whole blood provides the best currently available resuscitation strategy to reduce death from hemorrhage. This approach, which includes the use of resuscitation to blood pressure targets slightly below normal levels (80 mm to 90 mm Hg systolic) in order to minimize pressure-induced rebleeding—so-called “hypotensive resuscitation,” and the avoidance of crystalloids and colloids has been termed damage control resuscitation (DCR).⁹ It should be noted that our understanding of shock and coagulopathy continues to evolve and that optimizing patient monitoring in order to adjust ratios of blood products and hemostatic adjuncts, as well as their delivery over time, remains an area of active research.

HYPOTENSIVE RESUSCITATION

The duration of time from injury to surgical control of bleeding is an important factor in the appropriateness of applying hypotensive resuscitation strategies. Hypotensive resuscitation, particularly the avoidance of large-volume crystalloid use, has been shown to reduce death from hemorrhage for patients with penetrating injuries and with evacuation times under 30 minutes.¹⁰ It is unknown if this practice is advantageous for patients with evacuation times of over 60 minutes. The risk of shock and coagulopathy increases with a low cardiac output state, especially as the oxygen content of blood drops over time with bleeding and the loss of red blood cells (RBCs). As a result, caution is necessary when contemplating the appropriateness of hypotensive resuscitation in prolonged field care situations, as well as in particular clinical scenarios such as TBI. The validity of the current hypotensive resuscitation thresholds has also been questioned in the light of transfusion-based strategies that deliver improved hemostasis compared to crystalloid. In short, it is not clear whether hypotensive resuscitation offers any advantages if hemostatic blood products are available in the prehospital environment. Conversely, there is fairly strong evidence supporting avoidance of excess crystalloid through permissive hypotension when blood is not available and bleeding is not controlled.¹¹

HEMOSTATIC RESUSCITATION

A whole blood-based resuscitation with either whole blood or whole blood approximated with a 1:1:1 unit ratio

of RBCs, plasma, and platelet units provides a balanced treatment of both the shock and coagulopathy that together increase the risk of hemorrhagic death. It should be noted for planning purposes that the platelet units in “1:1:1” refer to platelet concentrate volumes from whole blood derived platelets (imagine literally reconstituting a unit of whole blood that has been separated by centrifugation into red cells, plasma and platelets – with anticoagulant and red cell additive solution added, thus diluting final product concentrations by about a third). Given that modern component use in the US military is exclusively based on platelets collected by apheresis, it might be more accurate to use the ratio of 6:6:1 (red cell units: plasma units: one apheresis platelet unit), but for the purposes of consistency with the literature, we retain the “1:1:1” terminology. In austere environments, whole blood is available through walking blood banks, where donors are typically screened with abbreviated questionnaires, and in some situations pre-screened for transfusion transmitted diseases prior to deployment. In this situation, the whole blood is collected and transfused within a very short period of time; therefore, it is termed warm fresh whole blood (WFWB). The rationale for the use of WFWB for resuscitation compared to the use of blood components is that it is more concentrated than one unit each of RBCs, plasma, and platelets, which contain three times the volume of anticoagulants and additive solutions and is more convenient in the prehospital setting. Warm fresh whole blood also has not developed the various storage lesions that reduce the efficacy and safety of stored blood components such as the well-known loss of labile coagulation factors and thrombin generation potential in thawed plasma, the loss of aggregation response in standard room temperature-stored platelets and the increased risk of bacterial growth in room temperature-stored platelets.^{12,14}

In an effort to increase the availability of whole blood, the effects of storage at 4°C have been re-evaluated. Whole blood has been found to retain most of its hemostatic function for up to 14 days.¹⁵ A potential advantage of this product compared to the approximation of whole blood with blood products in a 1:1:1 unit ratio is that the platelets in whole blood will be stored at 4°C and the platelet units used in approximated whole blood will be stored at 22°C. Previously published trial data in adults and children have indicated that platelet-containing products stored at 4°C are more hemostatically active compared to when they are stored at 22°C.¹⁴ Whole blood at 4°C would still be more concentrated than blood components in a 1:1:1 unit ratio, reducing the risk of dilutional coagulopathy.^{16,19} To further increase the availability of whole blood, particularly in emergency situations when cross-matching is difficult or impossible, it

is possible to use low anti-A, anti-B titer Group O whole blood as a universal donor product.²⁰

The widespread adoption of hemostatic resuscitation is evident in the findings of a recent survey of 132 US trauma centers, which reported that for adult trauma management, 88% of sites target high (1:2 or greater) plasma-to-RBC ratios. Likewise, 79% of sites target high platelet-to-RBC ratios. To facilitate the early transfusion of plasma, 69% of sites indicated that they have plasma immediately available for massive transfusion protocols (MTP) activation. A similar survey of MTP policies in children's hospitals revealed that 78% of centers targeted a high plasma:RBC ratio in children with life-threatening bleeding, whereas 65% of centers targeted a high ratio of platelets:RBCs. These survey data indicate that most adult and pediatric medical centers are attempting to deliver the functionality of whole blood with components.²¹

A meta-analysis of retrospective studies that evaluated the effect of high plasma ratios on outcomes in trauma patients indicated a survival benefit with early and increased plasma administration.²² However, as these types of studies are prone to several types of biases, including survivor bias and confounding by indication, the final word on the effect of high ratios on survival is unknown. There has been less data published regarding high platelet to RBC ratios, although most reports indicate improved survival, similar to the plasma:RBC ratio data.^{23,24}

Recently, the Pragmatic Randomized Optimal Platelet and Plasma Ratios (PROPPR) trial, a large prospective randomized trial compared a 1:1:1 ratio versus 1:1:2 in which the latter group received fewer platelets that were given later in resuscitation.²⁵ The study, while limited by the similarity of the treatment arms and which was determined by fading equipoise in the field, provided higher quality evidence than retrospective studies to support equal ratio component use and was able to show a difference in secondary outcomes of reduced death from hemorrhage at 24 hours and reduced time to hemostasis. Primary outcomes of mortality at 24 hours and 30 days were not different between the 2 study groups.

Further improvements in hemostasis and overall resuscitation outcomes may be possible since platelets stored at 22°C, the current standard of care, are less hemostatically functional than platelets stored at 4°C, and are also less safe due to the risk of bacterial contamination.^{26,27} Efforts are underway to make platelet units at 4°C available for patients with traumatic bleeding. The FDA and AABB in 2015 have permitted the use of apheresis

platelet units stored unagitated between 1°C and 6°C at the Mayo Clinic Trauma Center in Rochester, MN, for bleeding patients. In addition, clinical trials comparing platelets stored at 4°C vs 22°C are underway in Bergen, Norway, in patients undergoing complex cardiac surgery and experiencing severe bleeding. Cold-stored platelets have been designated an Army Strategic Technology Objective and could soon be deployed in support of combat operations.

In addition to improvements in platelets, the development of dried plasma products, such as freeze-dried (FDP) or spray-dried plasmas may provide important opportunities for improving prehospital resuscitation, particularly in austere settings where other blood products may be unavailable or inconvenient to collect on-site. While FDP was first fielded by US Forces in World War II and used as a bridge to whole blood transfusion, reintroduction of such a product to the clinical armamentarium requires FDA approval. The US Army Medical Research and Materiel Command, in partnership with the US Navy's Office of Naval Research and the Department of Homeland Security, has spearheaded efforts to obtain dried plasma products for trauma resuscitation. Development is advancing and clinical trials are currently underway. For the time being, US Army Special Operations Command troops have access to FDP manufactured by the French Army under an Expanded Access Investigational New Drug (IND) protocol. Execution of this protocol in the deployed setting is extremely cumbersome due to data management and reporting requirements and use has been extremely limited. The true utility of FDP and similar products will only be assessed once they are available off the IND protocol.

SYSTEMIC HEMOSTATIC ADJUNCTS

The logistical challenges of resuscitating trauma patients in remote settings often limit administration of blood products and have prompted the evaluation of hemostatic adjuncts. These medications may be particularly useful if intravascular volume is supported with crystalloid fluids, which cause dilutional coagulopathy.

Hemorrhage may be better controlled by improving clot stability. The CRASH-2 trial demonstrated that tranexamic acid (TXA), a lysine analog inhibitor of fibrinolysis, administered upon admission to hospital within 3 hours of injury, reduced all-cause mortality and death due to hemorrhage in trauma patients without causing an increase in venous thromboembolism.²⁸ The MATTERS and MATTERS-2 studies retrospectively evaluated TXA use in OEF combat casualties and found evidence of improved survival, although a

higher rate of venous thromboembolism was identified in unadjusted data in patients receiving TXA.^{29,30} Since earlier administration of TXA resulted in improved outcomes in CRASH-2, use in the prehospital setting is a reasonable extrapolation of the available clinical data.³¹ Furthermore, TXA has been shown to be stable across a wide range of environmental conditions that account for even very severe military operational settings.^{32,33} Tranexamic acid has thus been endorsed by the Blood Advisory Group of the North Atlantic Treaty Organization³⁴ as part of a protocol for the resuscitation of patients in hemorrhagic shock.³⁵

Another approach to hemorrhage control is centered on providing substrate for clot formation. Fibrinogen conversion to fibrin is the final common pathway of the coagulation system. Fibrinogen is rapidly depleted in the setting of massive trauma and hemorrhage due to hemodilution, consumption, and fibrinogenolysis.³⁶⁻³⁸ Fibrinogen concentrates appear to be relatively safe and can rapidly restore hemostatic function in some circumstances, thus reducing bleeding and transfusion requirements.^{39,40} In a large observational study of severely injured patients, the early use of fibrinogen concentrate was associated with significantly lower 6-h mortality and an increased time to death, but also a greater incidence of multiple organ failure.⁴¹ Randomized trials, particularly in the prehospital setting, are urgently needed to guide appropriate use of fibrinogen concentrates in trauma resuscitation.

Finally, increased thrombin generation has been suggested as an approach to improve hemorrhage control. Recombinant human factor VIIa has been evaluated in trauma and in other bleeding patient populations. While rFVIIa unquestionably increases thrombin generation and may reduce bleeding and RBC transfusion requirements to some extent, no mortality benefit has been demonstrated with use of this drug, and it associated with increased thromboembolic risk in certain patient populations (eg, elderly, active atherosclerotic vascular disease).^{42,43} Its use in trauma cannot be recommended outside of a clinical trial setting. Prothrombin complex concentrates (PCCs) have become the new standard of care in managing hemorrhage in patients receiving warfarin anticoagulation.⁴⁴ Use of PCCs in a broader population of trauma patients has not been evaluated in randomized controlled trials and may excessively increase thromboembolic risks due to the long half-lives of procoagulant factors in these products.⁴⁵ Animal studies suggest that PCCs may reduce blood loss but may also increase the risk of developing DIC and death.^{46,47}

Randomized controlled trials are required before the use of PCCs can be recommended for the broader trauma population.

CONCLUSION

The central tenets of damage control resuscitation, aggressive hemorrhage control, early treatment of shock and coagulopathy with blood products that deliver the functionality of whole blood, early administration of TXA,⁴⁸ and avoidance of crystalloid and colloid infusions have become the standard of care in combat casualty management. Further improvements in outcomes are possible with incorporation of products like cold-stored platelets, freeze- or spray-dried plasma, and fibrinogen concentrate, but the most important gains will be made through translation of DCR principles to the prehospital setting with therapies like point-of-injury whole blood transfusion. Additional gains will be possible through acquisition of a deeper understanding of the physiology of shock and coagulopathy which will permit enhanced patient selection and goal-directed therapy. Overall, reducing the time between an injury and hemostatic resuscitation remains the great challenge of battlefield medicine.

REFERENCES

1. EASTRIDGE BJ, MABRY RL, SEGUIN P, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. *J Trauma Acute Care Surg.* 2012;73(6 suppl 5):S431-S437.
2. KOTWAL RS, MONTGOMERY HR, KOTWAL BM, et al. Eliminating preventable death on the battlefield. *Arch Surg.* 2011;146(12):1350-1358.
3. CAP AP, PIDCOKE HF, DEPASQUALE M, et al. Blood far forward: time to get moving!. *J Trauma Acute Care Surg.* 2015;78(6 suppl 1):S2-S6.
4. PIDCOKE HF, ADEN JK, MORA AG, et al. Ten-year analysis of *Transfusion* in Operation Iraqi Freedom and Operation Enduring Freedom: increased plasma and platelet use correlates with improved survival. *J Trauma Acute Care Surg.* 2012;73(6 suppl 5):S445-S452.
5. DOBSON GP, LETSON HL, SHARMA R, SHEPPARD FR, CAP AP. Mechanisms of early trauma-induced coagulopathy: the clot thickens or not?. *J Trauma Acute Care Surg.* 2015;79(2):301-309.
6. CAP A, HUNT B. Acute traumatic coagulopathy. *Curr Opin Crit Care.* 2014;20(6):638-645.
7. CARDENAS JC, RAHBAR E, POMMERENING MJ, et al. Measuring thrombin generation as a tool for predicting hemostatic potential and transfusion requirements following trauma. *J Trauma Acute Care Surg.* 2014;77(6):839-845.

8. Cap A, Hunt BJ. The pathogenesis of traumatic coagulopathy. *Anaesthesia*. 2015;70(suppl 1):96-101.
9. Holcomb JB, Jenkins D, Rhee P, et al. Damage control resuscitation: directly addressing the early coagulopathy of trauma. *J Trauma*. 2007;62(2):307-310.
10. Bickell WH, Wall MJ Jr, Pepe PE, et al. Immediate versus delayed fluid resuscitation for hypotensive patients with penetrating torso injuries. *N Engl J Med*. 1994;331(17):1105-1109.
11. Morrison CA, Carrick MM, Norman MA, et al. Hypotensive resuscitation strategy reduces transfusion requirements and severe postoperative coagulopathy in trauma patients with hemorrhagic shock: preliminary results of a randomized controlled trial. *J Trauma*. 2011;70(3):652-663.
12. Spinella PC, Frazier E, Pidcoke HF, Dietzen DJ, Pati S, Gorkun O, et al. All plasma products are not created equal: Characterizing differences between plasma products. *J Trauma Acute Care Surg*. 2015;78(6 suppl 1):S18-S25.
13. Matijevic N, Kostousov V, Wang YW, et al. Multiple levels of degradation diminish hemostatic potential of thawed plasma. *J Trauma*. 2011;70(1):71-79; discussion 79-80.
14. Pidcoke HF, Spinella PC, Ramasubramanian AK, et al. Refrigerated platelets for the treatment of acute bleeding: a review of the literature and reexamination of current standards. *Shock*. 2014;41(suppl 1):51-53.
15. Strandenes G, Austlid I, Apelseh TO, et al. Coagulation function of stored whole blood is preserved for 14 days in austere conditions: a ROTEM feasibility study during a Norwegian antipiracy mission and comparison to equal ratio reconstituted blood. *J Trauma Acute Care Surg*. 2015;78(6 suppl 1):S31-S38.
16. Manno CS, Hedberg KW, Kim HC, et al. Comparison of the hemostatic effects of fresh whole blood, stored whole blood, and components after open heart surgery in children. *Blood*. 1991;77(5):930-936.
17. Becker GA, Tuccelli M, Kunicki T, Chalos MK, Aster RH. Studies of platelet concentrates stored at 22 C and 4 C. *Transfusion*. 1973;13(2):61-68.
18. Jobs D, Wolfe Y, O'Neill D, et al. Toward a definition of "fresh" whole blood: an in vitro characterization of coagulation properties in refrigerated whole blood for transfusion. *Transfusion*. 2011;51(1):43-51.
19. Pidcoke HF, McFaul SJ, Ramasubramanian AK, et al. Primary hemostatic capacity of whole blood: a comprehensive analysis of pathogen reduction and refrigeration effects over time. *Transfusion*. 2013;53(suppl 1):137S-149S.
20. Strandenes G, Berseus O, Cap AP, et al. Low titer group O whole blood in emergency situations. *Shock*. 2014;41(suppl 1):70-75.
21. Camazine MN, Hemmila MR, Leonard JC, Jacobs RA, Horst JA, Kozar RA, et al. Massive transfusion policies at trauma centers participating in the American College of Surgeons Trauma Quality Improvement Program. *J Trauma Acute Care Surg*. 2015;78(6 suppl 1):S48-S53.
22. Murad MH, Stubbs JR, Gandhi MJ, et al. The effect of plasma transfusion on morbidity and mortality: a systematic review and meta-analysis. *Transfusion*. 2010;50(6):1370-1383.
23. Holcomb JB, Wade CE, Michalek JE, et al. Increased plasma and platelet to red blood cell ratios improves outcome in 466 massively transfused civilian trauma patients. *Ann Surg*. 2008;248(3):447-458.
24. Perkins JG, Cap AP, Spinella PC, et al. An evaluation of the impact of apheresis platelets used in the setting of massively transfused trauma patients. *J Trauma*. 2009;66(suppl 4):S77-S84; discussion S84-S85.
25. Holcomb JB, Tilley BC, Baraniuk S, et al. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma: the PROPPR randomized clinical trial. *JAMA*. 2015;313(5):471-482.
26. Reddoch KM, Pidcoke HF, Montgomery RK, et al. Hemostatic function of apheresis platelets stored at 4 degrees C and 22 degrees C. *Shock*. 2014;41(suppl 1):54-61.
27. Nair PM, Pidcoke HF, Cap AP, Ramasubramanian AK. Effect of cold storage on shear-induced platelet aggregation and clot strength. *J Trauma Acute Care Surg*. 2014;77(3 suppl 2):S88-S93.
28. de Guzman R, Polykratis IA, Sondeen JL, Darlington DN, Cap AP, Dubick MA. Stability of tranexamic acid after 12-week storage at temperatures from -20 degrees C to 50 degrees C. *Prehosp Emerg Care*. 2013;17(3):394-400.
29. Morrison JJ, Dubose JJ, Rasmussen TE, Midwinter MJ. Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study. *Arch Surg*. 2012;147(2):113-119.
30. Morrison JJ, Ross JD, Dubose JJ, Jansen JO, Midwinter MJ, Rasmussen TE. Association of cryoprecipitate and tranexamic acid with improved survival following wartime injury: findings from the MATTERs II Study. *JAMA Surg*. 2013;148(3):218-225.
31. Lipsky AM, Abramovich A, Nadler R, et al. Tranexamic acid in the prehospital setting: Israel Defense Forces' initial experience. *Injury*. 2014;45(1):66-70.

CHANGES IN EQUIPMENT AND TECHNIQUES/TACTICS/PROCEDURES
THAT IMPACTED CARE AND OUTCOMES

32. Floccard B, Rugeri L, Faure A, et al. Early coagulopathy in trauma patients: an on-scene and hospital admission study. *Injury*. 2012;43(1):26-32.
33. Darlington DN, Craig T, Gonzales MD, Schwacha MG, Cap AP, Dubick MA. Acute coagulopathy of trauma in the rat. *Shock*. 2013;39(5):440-446.
34. Heier HE, Badloe J, Bohonek M, et al. Use of tranexamic acid in bleeding combat casualties. *Mil Med*. 2015;180(8):844-846.
35. Schlimp CJ, Voelckel W, Inaba K, Maegele M, Ponschab M, Schochl H. Estimation of plasma fibrinogen levels based on hemoglobin, base excess and Injury Severity Score upon emergency room admission. *Crit Care*. 2013;17(4):R137.
36. Schochl H, Schlimp CJ. Trauma bleeding management: the concept of goal-directed primary care. *Anesth Analg*. 2014;119(5):1064-1073.
37. Rahe-Meyer N, Solomon C, Hanke A, et al. Effects of fibrinogen concentrate as first-line therapy during major aortic replacement surgery: a randomized, placebo-controlled trial. *Anesthesiology*. 2013;118(1):40-50.
38. Wafaisade A, Lefering R, Maegele M, et al. Administration of fibrinogen concentrate in exsanguinating trauma patients is associated with improved survival at 6 hours but not at discharge. *J Trauma Acute Care Surg*. 2013;74(2):387-383; discussion 393-395.
39. Lin Y, Stanworth S, Birchall J, Doree C, Hyde C. Recombinant factor VIIa for the prevention and treatment of bleeding in patients without haemophilia. *Cochrane Database Syst Rev*. 2011;16(2):CD005011.
40. Yank V, Tuohy CV, Logan AC, et al. Systematic review: benefits and harms of in-hospital use of recombinant factor VIIa for off-label indications. *Ann Intern Med*. 2011;154(8):529-540.
41. Patriquin C, Crowther M. Treatment of warfarin-associated coagulopathy with vitamin K. *Expert Rev Hematol*. 2011;4(6):657-665; quiz 666-667.
42. Honickel M, Rieg A, Rossaint R, et al. Prothrombin complex concentrate reduces blood loss and enhances thrombin generation in a pig model with blunt liver injury under severe hypothermia. *Thromb Haemost*. 2011;106(4):724-733.
43. Grottke O, Braunschweig T, Spronk HM, et al. Increasing concentrations of prothrombin complex concentrate induce disseminated intravascular coagulation in a pig model of coagulopathy with blunt liver injury. *Blood*. 2011;118(7):1943-1951.
44. Kragh JF Jr, Walters TJ, Baer DG, et al. Practical use of emergency tourniquets to stop bleeding in major limb trauma. *J Trauma*. 2008;64(suppl 2):S38-S49; discussion S50.
45. Schochl H, Voelckel W, Maegele M, Kirchmair L, Schlimp CJ. Endogenous thrombin potential following hemostatic therapy with 4-factor prothrombin complex concentrate: a 7-day observational study of trauma patients. *Crit Care*. 2014;18(4):R147.
46. Dickey NW. Combat Ready Clamp Addition to the Tactical Combat Casualty Care Guidelines 2011-07. Falls Church, VA: Defense Health Board; September 23, 2011. Available at: <http://www.health.mil/Reference-Center/Reports/2011/09/23/Combat-Ready-Clamp-Addition-to-the-Tactical-Combat-Casualty-Care-Guidelines>. Accessed February 10, 2016.
47. Adams HA, Baumann G, Gansslen A, et al. [Definition of shock types] [in German]. *Anesthesiologie Intensivmedizin Notfallmedizin Schmerztherapie*. 2001;36(suppl 2):S140-S143.
48. Ausset S, Glassberg E, Nadler R, et al. Tranexamic acid as part of remote damage-control resuscitation in the prehospital setting: A critical appraisal of the medical literature and available alternatives. *J Trauma Acute Care Surg*. 2015;78(6 suppl 1):S70-S75.

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Theater Blood Support in the Prehospital Setting

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ABSTRACT

The Army Blood Program (ABP) is charged with the responsibility of supporting the Warfighter on the battlefield, in addition to meeting garrison hospital blood requirements on a daily basis. Blood support concepts developed in response to Operation Iraqi Freedom/Operation Enduring Freedom combat operations are the cornerstone to maintaining current capabilities and shaping future endeavors. The ABP is actively engaged with research, advanced development of blood products and medical technology to improve blood safety and efficacy for both our conventional and operational forces. The feasibility of frozen/deglycerolized red blood cell use in theater has been demonstrated. The use of Blood Group A plasma in the place of Blood Group AB plasma has been successful. Placement of cryoprecipitate at Role 2 medical facilities and the placement of blood products on MEDEVAC (Vampire Program missions) have proven invaluable in moving transfusion therapy closer to the point of Injury. The improved patient outcomes from earlier transfusion of blood products has driven the requirement for far-forward blood support. Now (more than ever), there are products and processes in place to meet the requirements for blood use in the prehospital setting.

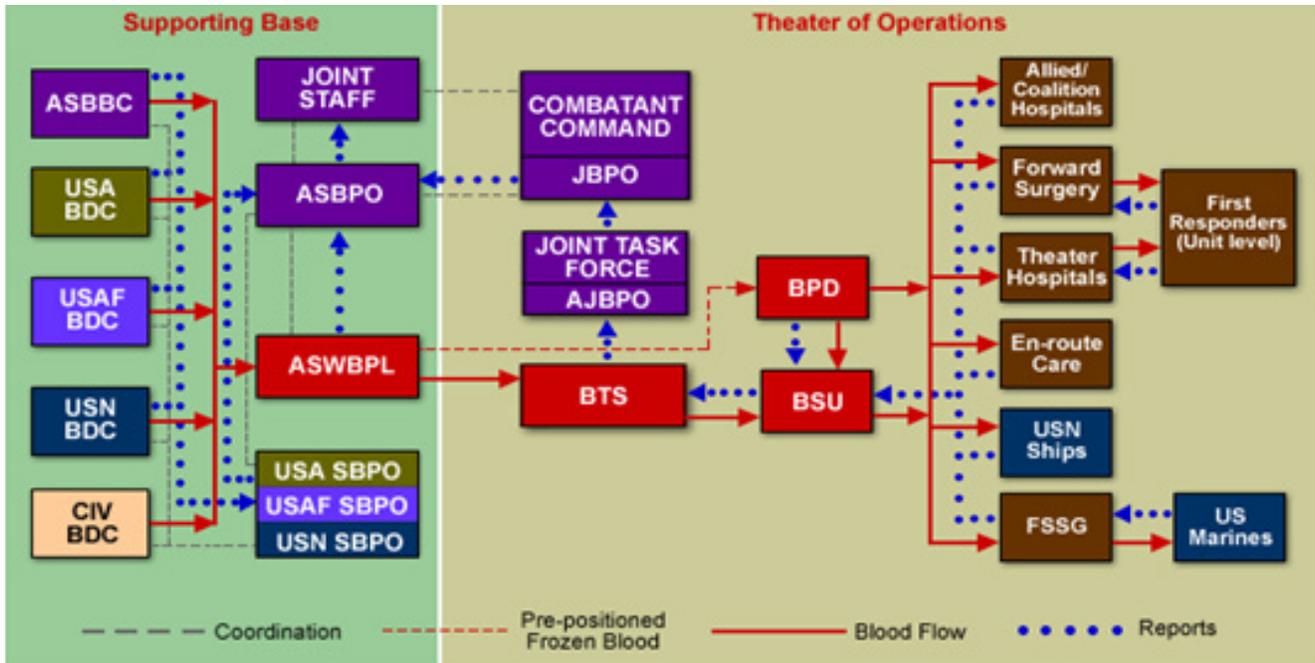
The overall mission of the Armed Services Blood Program (ASBP) is to provide quality blood products and services for all worldwide customers in peace and war. The standard blood distribution system used by ASBP provides a solid framework for the 3 service blood programs to move blood and blood products to designated, in-theater medical care activities, treatment facilities, and first responders as illustrated in Figure 1.^{1,2} While the distribution system works very well when established in support of theater operations, stringent storage and shipping requirements, inventory management, and limited potency periods have a continuous influence on the ability to provide this required support.² Despite these constraints and in response to documented lessons learned, several improvements on the blood program have already been made. Supporting units have become more flexible, inventory management has been enhanced, Hemacool refrigerators and freezers (AcuTemp Thermal Systems, Moraine, Ohio) are found at Role 2, apheresis platelets are collected in theater, aggressive collections in the United States have resulted in fresher blood on the shelf in theater, and protocols have been established to standardize transfusion ratios and the emergency collection of whole blood. These efforts alone have contributed immensely to the noted improved survival rates on the battlefield. However, the work and advances must continue in order to sustain current practice with our conventional forces as well as continue to focus

on extending the required support beyond the current distribution system to those closest to the point of injury—the first responders. The determination of blood types through use of Eldon ABO cards and development of the Micronics ABORh card (both approved by the Food and Drug Administration (FDA) for educational use) has allowed the capability to determine blood types of donors and closed the gap of depending on dog tags with a known error rate of 3%-5%.³ A capability gap in ensuring safe blood products led to the whole blood pathogen reduction device (PRD) development effort. As of 2011, PRD is an official Program of Record for the Department of Defense (DoD) which will enhance blood safety efforts in support of future capabilities.

FREEZE DRIED PLASMA

While the theater blood management of FDA licensed products has been successful, frozen plasma products are only available doctrinally at Role 2 and Role 3 MTFs due to logistical constraints. With the long logistical tail, breakage rates of fresh frozen plasma (FFP) sometimes exceeded 25%, rendering a precious product useless. Research and development efforts have been vital to the future success in combating these constraints and supporting damage control resuscitation (DCR). The development of a dried plasma product would eliminate the need for shipping at ultra-low temperatures and unacceptable loss of product due to breakage. Freeze dried

PERSONNEL CHANGES THAT IMPACTED CARE AND OUTCOMES



Glossary

ASBBC - Armed Services Blood Bank Center
 BDC - Blood Donor Center
 ASBPO - Armed Services Blood Program Office
 ASWBPL - Armed Services Whole Blood Processing Laboratory
 JBPO - Joint Blood Program Officer

AJBPO - Area Joint Blood Program Officer
 BTS - Blood Transshipment System
 BPD - Blood Product Depot
 BSU - Blood Supply Unit
 FSSG - Force Service Support Group

Figure 1. US Military Blood Distribution and Reporting System. Adapted from *Technical Manual TM 8-227-12: Joint Blood Program Handbook*.¹

plasma (FDP) provides tremendous advantages in battlefield DCR beginning at the POI. Once reconstituted, this product combats the coagulopathy of trauma and restores circulatory volume.

Freeze dried plasma will be used to treat life threatening, severe hemorrhage arising from injuries sustained during contingency operations in remote, austere environments where access to standard blood products and immediate damage control surgery is not readily available. The US military has identified an operational need for an FDP product on the battlefield as noted in an approved Capabilities Development Document. Department of Defense requirements have been identified and collaboration efforts are underway with private industry to develop a product approved by the FDA. In the meantime, the US Army Special Operations Command has an immediate need and, under an Expanded Access Investigational New Drug (IND) protocol, has been granted permission from the FDA to procure this type of product from the French Military Blood Bank (also referred to as Centre de Transfusion Sanguine des Armees (CTSA)).^a The CTSA provides a very limited

amount of FDP due to a limited donor pool in France. A novel collaborative approach among the Special Operations Command, the Army Medical Research and Material Command, the Army Blood Program (ABP), and CTSA has been in the works to amend the Expanded Access IND to provide apheresis plasma collected by the ABP as the source material for CTSA to manufacture FDP. To date, 5 ABP Blood Donor Centers are collecting plasma for this program. Freeze dried plasma will provide blood support at the POI, will reduce current wastage of FFP due to breakage and outdating, does not require cold chain management, and can be used by both conventional and special operations forces.

BLOOD GROUP O LOW TITER WHOLE BLOOD

The requirement for the collection and transfusion benefits of whole blood in emergency conditions is well known and documented. The evolution of this practice has resulted in the development of a Clinical Practice Guideline for Fresh Whole Blood Collections⁴ by the US Central Command and identified the need for a standardized training platform. Current practice includes the collection and transfusion of type specific whole

a. Information paper. Subj: Relationship Between the French Military Blood Program and the US Army; November 4, 2013. Internal military document not readily accessible by the general public.

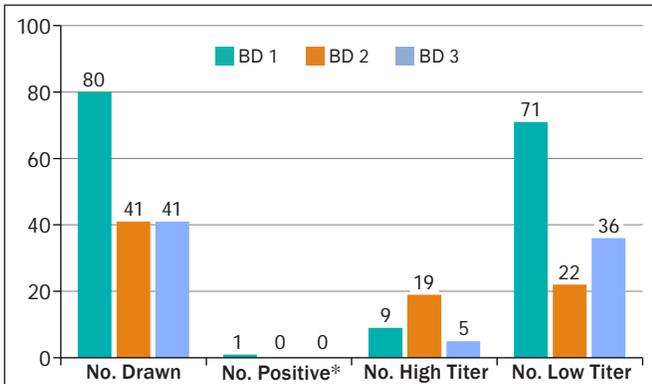


Figure 2. Titer results from the first 3 collections at Fort Benning. BD indicates blood draw. Data provided by S. Rudesheim, Sullivan Memorial Blood Center, Fort Benning, GA.
*Positive results for the FDA mandated Transfusion Transmission Disease Testing.

blood, however, the ability to obtain the blood type of a potential donor can be problematic. The 75th Ranger Regiment Trauma Management Team (Tactical) at Fort Benning, Georgia, has partnered with the ABP to deploy with identified low titer Group O donors. This program has evolved throughout FY15 and includes completion of the DD Form 572 (Donor Screening Record) and interview process for volunteer low titer Group O Soldiers assigned to the regiment, the collection of tubes for the required viral marker and titer testing, establishment of the unit in the Theater Medical Data Store (TMDS) for theater access by the Regimental Surgeon of results, and appropriate donor follow-up and counseling in the event of a positive test. This collaborative effort was initiated in conjunction with the Sullivan Memorial Blood Donor Center at Fort Benning. The Fort Benning donor collection team has worked to streamline the process and develop a standard operating procedure to be used in support of Rangers assigned to Joint Base Lewis McChord and Hunter Army Air Field.^b This program also involves the Department of Pathology at each location in order to process, ship, and enter the requested titer results in the Composite Health Care System. Group O Rangers with a titer of 1:256 or greater are considered “high titer” and will not be used as donors. Group O Rangers with a titer less than 1:256 are considered “low titer” and may be used as donors. Titer results of the first 3 collections are shown in Figure 2.^c Donor interview is documented on the DD Form 572: Blood Donation Record. Transfusion transmitted disease testing, and titer testing results are entered into TMDS by the donor center staff. This step closes the loop and provides

visibility to the Regimental Surgeon or designee. As this program continues to mature, approximately one half of the potential blood Group O donors should be identified as low titer.

THE VAMPIRE PROGRAM

The current Vampire Program, established in 2012, allows the transfusion of blood products on MEDEVAC rotary wing aircraft during combat operations by flight medics, registered nurses, physicians, and physician assistants for patients with appropriate indications.^d These MEDEVAC medical personnel are authorized to administer blood products in accordance with the approved protocol in theater. Identified personnel must complete the initial training program, which provides familiarization with the indications for transfusion, recognition, and treatment of reactions and administrative requirements. Refamiliarization is required every 3 months. Standard blood products used in this program include Group O packed red blood cells (pRBCs) and group A thawed FFP. Both products require refrigeration and are issued and transported in the approved “golden hour box.” Upon issue, MEDEVAC medical personnel assume all responsibility for the products and the appropriate documentation. Transfusions must be ordered by a physician and appropriately documented in the patient’s chart. Transfusion activities must be documented in TMDS and documentation placed in the patient’s medical record. The medical detachment blood support (MDBS) commander also maintains oversight of this program and reports any problems to the joint blood program officer on a weekly basis. Approximately 320 units of pRBCs and 20 units of thawed FFP have been transfused as of this writing. There will be a continued need for this program as one avenue to provide life-saving measures in the prehospital setting. As new FDA approved blood products are made available within industry, a future product menu for the Vampire Program may include FDP, cold stored apheresis platelets, and cold stored whole blood.

COLD PRODUCTS: WHOLE BLOOD, APHERESIS PLATELETS AND LIQUID PLASMA

Whole blood is a product that is not routinely stored in theater beyond 24 hours. The current initiative to identify Group O low titer donors with the 75th Ranger Regiment will lay the foundation for the collection and storage of Group O low titer units to support our conventional forces. The current Clinical Practice Guidelines

Sources are internal military documents not readily accessible by the general public:

- b. Draft Standard Operating Procedure: Ranger Titer Testing. Fort Benning, GA: Sullivan Memorial Blood Center; August 2015.
- c. Ranger Titer Results and Graph. Fort Benning, GA: Sullivan Memorial Blood Center; July 2015.
- d. Malsby RF, Shackelford S, Coots NV. SOP for Management and Administration of Blood Products on Army MEDEVAC Missions, version 3. US Forces – Afghanistan; August 2012.

allow for the transfusion of type-specific whole blood. A shift to the collection, testing, storage, and distribution of Group O whole blood in theater at Role 2 facilities will have a huge effect on current inventory constraints and allow the ASBP to provide the right product to the right patient.⁴ Fresh whole blood contains platelets and may also be incorporated into the current Vampire Program.

Apheresis platelets are collected in theater due to their 5-day expiration. Upon collection, platelet products are maintained at room temperature in an incubator (with gentle agitation) while a deployed Role 3 medical facility provides microbiology support for bacterial contamination testing. Despite being collected in theater, the availability of this product is still limited to Role 3 medical facilities and the MDBS.² As operations move to more austere environments and efforts continue to provide blood support in these locations, storing this resource-intensive product in a refrigerator will assist in this endeavor. The blood industry has noted that specific platelet products may target specific clinical indications. Room temperature platelets are important for those patients with chronic conditions, while cold stored platelets are good for trauma patients. In addition to the significant decrease in required resources to maintain this blood component, the Army Institute of Surgical Research has conducted a tremendous amount of research with this product and noted that cold stored platelets provide better hemostatic function.⁵ The FDA has recently approved the use of 3-day, apheresis cold stored platelets. This is definitely a significant step in the right direction as research continues to focus on extending the expiration date of cold stored platelets with the addition of platelet additive solutions. The ability to store cold apheresis platelets that are fully tested and FDA licensed would create the capability to ship this product to the theater of operations through the Armed Services Blood Distribution System.

The ASBP has received a few requests for liquid plasma to support exercises and operations. This whole blood derived product has a 26-day expiration date, is ideal for those Role 2 medical facilities without thawing

capability, and is stored in a refrigerator at the same temperature as pRBCs and thawed FFP. Since this product is not widely used, the procurement of it by ASBP requires a significant amount of lead time. The 3 service blood programs are currently working on licensure packets to routinely provide this product. Once licensed with ASBP, this product will be more readily available with less lead time required for collection and distribution

PREDEPLOYMENT TRAINING

Training plays a vital role in the successful execution of donor collections and transfusion activities. In the absence of a formalized training platform, laboratory officers and the service blood programs will work together to facilitate training for laboratory personnel preparing to deploy. This process will work for active duty personnel, but does not capture reserve personnel and, as a result, a significant amount of training is completed in theater. The ABP submitted a request in 2011 to develop a formalized training course to provide training on the collection of whole blood, collection of apheresis platelets, and deglycerolization of frozen blood. Future plans include the availability of the course in the Army Training Requirements and Resource System and attendance by personnel from the Army, Navy, and Air Force.

CONCLUSION

As the ABP continues to be engaged with research and advanced development, partnerships with industry and other alliances are vital to the continued success and efforts to provide blood support in the prehospital setting. Freeze dried plasma is available to US Army Special Forces, the 75th Ranger Regiment can now deploy with known Blood Group O low titer donors, and the FDA has approved cold stored apheresis platelets. This collaborative type of effort must continue as we work diligently to decrease cold chain management requirements, provide pathogen reduction technology, and move blood products further forward on the battlefield into the prehospital setting. Lessons learned by the ABP will have significant effect on future doctrine and training.

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REFERENCES

1. *Technical Manual TM 8-227-12: Joint Blood Program Handbook*. Falls Church, VA: Armed Services Blood Program Office; December 1, 2011. Available at: http://armypubs.army.mil/med/DR_pubs/dr_a/pdf/tm8_227_12.pdf. Accessed February 12, 2016.
2. *Joint Publication 4-02: Health Service Support*. Washington, DC: Office of the Chairman, Joint Chiefs of Staff; July 2012. Available at: http://www.dtic.mil/doctrine/new_pubs/jp4_02.pdf. Accessed February 11, 2016.
3. Rentas FJ, Clark PA. Blood type discrepancies on military identification cards and tags: a readiness concern in the US Army. *Mil Med*. 1999;164(11):785-787.
4. Joint Trauma System Clinical Practice Guideline: Fresh Whole Blood Transfusion. Fort Sam Houston, Texas: US Army Institute of Surgical Research; 2012. Available at: http://www.usaisr.amedd.army.mil/cpgs/Fresh_Whole_Blood_Transfusion_24_Oct_12.pdf. Accessed February 26, 2016.
5. Cap AP. Platelet storage: a license to chill!. *Transfusion*. 2016;56(1):13-17.

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Shaping the Flight Paramedic Program



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ABSTRACT

Over the past 14 years of conflict, the Department of Defense medical community has made significant strides in patient care. As the conflicts developed, many sources identified a critical gap in en route care, specifically the need for critical care trained personnel for point of injury and intrahospital transfers, as well as improved outcomes for patients who received care from critical care trained providers. As stopgap measures were implemented, the US Army instituted the Critical Care Flight Paramedic Program in order to meet this need of life saving critical care transport. Execution of both an institutional training model as well as a home station training option allows for increased numbers of personnel trained, as well as flexibility for National Guard and Army Reserve units to keep personnel in their area. The Critical Care Flight Paramedic Program's educational outcomes have been exceptional, with National Registry Paramedic pass rates well above the national average. As the program develops, recertification and sustainment of knowledge and skills will be challenges, and novel approaches and flexibility will become critical for continued success.

BACKGROUND

After September 11, 2001, the Army transitioned from a peacetime Army to one in continuous wartime operations. As our conflicts have continued, there have been many significant changes and improvements in combat casualty care from the point of injury to rehabilitation of Wounded Warriors to the first ever critical care transport by Army combat medics. This manuscript attempts to capture the observations and decisions that led to the creation of the Army's Critical Care Flight Paramedic (CCFP) Program and how it is being shaped to meet future requirements.

At the initiation of the conflicts after 9/11, Army Aero-medical Evacuation units were staffed with one medical provider for en route care. This provider (flight medic) was trained with the certification level of an Emergency Medical Technician (EMT) Basic. Additionally, the flight medic received training at the Army School of Aviation Medicine on aircrew functions and Advanced Cardiac Life Support, Pediatric Education for Prehospital Professionals, and International Trauma Life Support. This training was 6 weeks long and upon completion the medic became a flight medic with the skill qualification identifier of "F."

The experiences, advice, and decisions that led to the creation of the program occurred over the course of several years. Initially, anecdotal evidence and after action reviews from providers in Iraq and Afghanistan noted that during the course of medical evacuation, postoperative patients transferred from a forward surgical team were critically ill and required significant in-flight medical management, such as ventilator management,

provision of multiple medications, and blood administration. The flight medic was not trained to deliver this level of care and although many would learn these skills on the job, it was not a stated requirement to do so. Because medics were not trained in en route care, another medical provider, ie, physician, physician assistant, or critical care nurse, would have to accompany the patient during medical evacuation. This caused several potential problems: new providers were typically not familiar with aircrew procedures which could potentially cause issues while in flight, were unfamiliar with providing care in a nonhospital environment, and most importantly, were lost to the units for a lengthy period of time before they could make their way back.

Medical leaders identified these gaps through various channels and initiated efforts to change the paradigm. One of the Army solutions was the creation of the En route Critical Care Nurse (ECCN) program, which trained critical care nurses to accompany critically ill patients during intrafacility transport. The ECCNs were initially assigned to one of the medical treatment facilities, however, as time progressed, the ECCNs were eventually attached to the air ambulance units where they could develop relationships with the flight medics and aircrews, to great success. This change in assignment contributed greatly to the success of the program because the ECCN became more familiar with the providers and other unit personnel and could assist with point of injury responses.

Although the employment of the ECCN markedly enhanced the level of en route care, a larger issue remained. Because ECCNs were never assigned to air ambulance units, there was no guarantee that ECCNs would be

trained and available for deployment in future conflicts. The logical solution to this problem was to ensure that the provider assigned to the unit, the flight medic, has the necessary skills and knowledge to perform the essential en route care, which is standard practice within the US civilian air evacuation community.

Anecdotal evidence from after action reports assessing en route care continued to mount over the course of combat operations. However, there was little evidence to support that staffing evacuation platforms with medical providers who had a level training above that of a flight medic resulted in improved patient outcomes.¹ This changed in 2011, when the *Journal of Trauma* published the paper “Impact of critical care trained flight paramedics on casualty survival during helicopter evacuation in the current war in Afghanistan”.² The study showed patient survival at 48 hours was 66% higher when patients were transported by critical care trained crews as compared to patients transported by crews who were not trained in critical care. This strongly supported the recommendation that critical care training should become the standard for MEDEVAC medical providers.

In 2010, the Army Medical Department Center and School (AMEDDC&S) and the US Army School of Aviation Medicine convened a Flight Medic Critical Task selection board which determined that the requisite skill level for a flight medic should be a paramedic with certain additional skills. Shortly thereafter, The Army Surgeon General, based upon a recommendation from the AMEDDC&S Commanding General, decided that the flight medic would be trained as a paramedic with critical care training. The Army codified this series of decisions in ALARACT* 061/2012 which provided notification of the requirement and intent to train 68W Flight Medics to NREMT-P[†] standards with critical care training. Additionally, the FY13 National Defense Authorization Act³ (NDAA) directed the Secretary of the Army to implement a requirement to have “all in-flight medical care providers to be critical care flight paramedic (CCFP) certified within the next 3 years.”

ESTABLISHMENT

The development of the institutional model started with the creation of the Critical Care Flight Paramedic Program at AMEDDC&S in late 2011. The first pilot course for National Registry Paramedic (NRP) certification was conducted at the University of Texas Health Science

Center San Antonio (UTHSCSA) from February to August of 2012. This course follows the National Registry of Emergency Medical Technician guidelines for the medical curriculum taught by the faculty at UTHSCSA. The first time pass rate of the NRP exam was 92% (historical average across the United States in 2012 was 74%), and since inception has always remained above 90%. Upon completion of the NRP course, students transitioned directly to the critical care course, with the didactic portion conducted at UTHSCSA, and critical care clinical rotations at the San Antonio Military Medical Center. Each student completed 240 hours of clinical rotations which significantly exceeded the number of hours in civilian critical care courses for paramedics. The justification for this number of hours was that in the civilian air ambulance community, a paramedic generally will not be considered for hire with less than 3-5 years of experience as a ground paramedic. Given the potential for an Army Medic to not have the clinical patient experience that a full time paramedic would have, the increase in patient encounters during training would provide an equivalent experience that a civilian would accumulate in 3 to 5 years.

The third training course was the integration of medical training in the aviation environment coupled with aircraft crewmember training. Given that the initial paramedic students were already MEDEVAC crewmembers and therefore been to the legacy flight medic course (with the additional skill identifier (ASI) of F3), crewmember training would not be a requirement for them. However, natural attrition of medics required that new medics, who were not trained as MEDEVAC crewmembers, must attend this training. Initially, these students went to the legacy flight medic course until a new course could be created for the flight paramedics.

HOME STATION TRAINING

As the institutional model was created, it became apparent that it would not be possible to meet the throughput necessary to meet the FY13 NDAA directive. Given that the civilian community has many facilities to provide the training necessary to obtain NRP certification and critical care training, the Army created the Home Station Training option. This option, outlined in ALARACT 028/2013 and updated in ALARACT 301/2013, allowed units to send Soldiers to an accredited civilian NRP program as well as civilian critical care programs (with the approval of the director of the CCFP Program). This provides flexibility for units and Soldiers to obtain the training without having to change duty stations. This is extremely beneficial to Soldiers assigned to air ambulance units that may be pending a deployment cycle. Additionally, this option is advantageous for National

*All Army Activities: a message transmitted to all US Army activities throughout the world, providing announcements, notifications, and other information of import requiring rapid dissemination Army-wide.

[†]National Registry of Emergency Medical Technicians-Paramedic

Guard and Reserve unit Soldiers whose civilian employment would be severely disrupted for an individual training event. This model may become more attractive in the years to come as we try to meet the goal of having every inflight provider be a CCFP.

CURRENT TRAINING

The current institutional model consists of contracted courses from UTHSCSA. The NRP course is 6 months in length and culminates with the student taking the NRP exam. Upon passing the exam, the student transitions to the critical care course, which is 8 weeks long. The current contracted course differs from the pilot in that the clinical rotations are done with civilian facilities and agencies, broadening the students' experience.

The third course required for those students who have not received the ASI F3 in the past is the new AMEDD Aviation Crewmembers Course. The purpose of this course is twofold: first to "operationalize" the medical knowledge that the students have in the aircraft environment, and second, to introduce the student to the aviation environment and the crewmember skills necessary to become an effective crewmember on an aircraft. The first pilot of this course was conducted in July 2015, and student feedback has been overwhelmingly positive.

FUTURE

As stated earlier, the initial goal of the program was to transition all Army flight medics to CCFP by FY 2017. For a variety of reasons (deployments, funding for pay and allowances for National Guard/Reserve, throughput capability), the likelihood of meeting this goal is low. However, significant progress has been made, and attention is being focused at the highest levels to ensure the program continues to provide for training of this critical skill set.

As the program matures, there will likely be a transition of the contracted courses to bring the training into the AMEDDC&S. One advantage of this would be that the instructors will be primarily CCFPs with deployment experience which would bring real world experience to students. Another advantage would be the ability to integrate training in the aircraft cabin environment using the newly constructed Transport Medical Training Lab (TMTL) at AMEDDC&S. The TMTL enables students to integrate all the skills learned using high fidelity patient simulators in a realistic aircraft environment. Instructors are able to record all of the students' interventions with the simulated patient ensuring a thorough evaluation is provided. Additionally, there is a forward surgical team "suite" in which the student will be able to hand over and receive patients from hospital

providers, so the first time they conduct such handovers will not be in a deployed environment. This will also allow other providers to rehearse and train in a more realistic environment while at AMEDDC&S. The San Antonio Military Medical Campus, as well as civilian hospitals and other civilian agencies, will still be part of the CCFP training through the use of Medical Training Agreements in order to ensure the students have a breadth of clinical experience prior to seeing a critically ill or injured patient on their own. Finally, the ability to integrate the other agencies at AMEDDC&S, such as the veterinary instructors, allow for integration of military specific training requirements into the program.

CHALLENGES

One of the main challenges in creating the CCFP is the "tail" of sustainment and recertification training. Army Emergency Medical Service currently has an interim recertification policy that is outlined in ALARACT 071/2014, which meets the requirements of NREMT recertification for NRP. Although it meets the requirements, many of the interventions and much of the knowledge outlined in the policy fail to address the needs for sustainment of the CCFP. Currently the CCFP Program is working on a solution through the creation of a training circular (TC) similar to TC8-800 for 68Ws (combat medics), but focused on the CCFP needs. Additionally, getting sustainment clinical training in a high acuity environment (ICU level care) will be necessary to maintain clinical acumen. This will require medical training agreements (MTA) between units and military treatment facilities (MTF) or civilian hospitals, as many local MTFs do not have the patient level of acuity for the CCFP to maintain clinical knowledge and skills. This will require leaders at separate posts to take the lead in integrating with the outside community, which is already happening at locations like Fort Hood, where the leadership has approved MTAs with civilian agencies, enabling their medics to acquire patient care experience.

As the transition to Critical Care Flight Paramedics continues to progress, other challenges will become evident. Given the successful history of the rapid development of this program, these challenges will likely become opportunities to improve on the program and allow for future success. Early identification of the gaps in en route care, followed by parallel initiatives from multiple sources, have shown that developing a highly skilled en route care provider can be done effectively. Challenges in the future, primarily concerning sustainment of these skills, will likely be met through innovative institutional and organizational solutions in order to maintain the capability to take care of the most critically ill and injured patient.

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REFERENCES

1. Cearnal L. Emergency physicians highlight, “Army-wide emergency medical care deficiency” in training of flight medics. *Ann Emerg Med.* 2008;52:522-524.
 2. Mabry RL, Apodaca A, Penrod J, Orman JA, Gerhardt RT, Dorlac WC. Impact of critical care-trained flight paramedics on casualty survival during helicopter evacuation in the current war in Afghanistan. *J Trauma Acute Care Surg.* 2012;73(2 suppl 1):S32-S37.
 3. Pub L No. 112-239, National Defense Authorization Act for Fiscal Year 2013; January 2, 2013.
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US Army Physical Therapist Roles and Contributions in Operations Enduring Freedom and Iraqi Freedom

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ABSTRACT

Musculoskeletal injuries are a leading cause of health care utilization, medical evacuation, and disability. US Army physical therapists (PTs) have served as physician extenders for the management of nonsurgical neuromusculoskeletal injuries since the Vietnam conflict. The roles and evidence supporting US Army physical therapy continue to evolve. This article discusses the different levels of care and roles of US Army PTs, the contributions and evidence regarding US Army physical therapy, and physical therapy lessons learned during Operations Enduring Freedom and Iraqi Freedom. Since 2001, US Army PTs and enlisted physical therapy technicians have provided care from Levels 1 to 5 and assignments have expanded to special operations and brigade combat teams. Evidence suggests US Army PTs serving both in referral and direct access roles provided safe and definitive care that maximized readiness while reducing evacuation. Key physical therapy lessons learned include: (1) a continued focus on a Soldier sports medicine forward care model, (2) a need for injury risk assessment, physical performance screenings, and reconditioning programs that optimize readiness, and (3) continued support for physical therapy structure, training, and research that maximizes Soldier readiness and health.

PROBLEM STATEMENT: IMPACT OF MUSCULOSKELETAL INJURIES

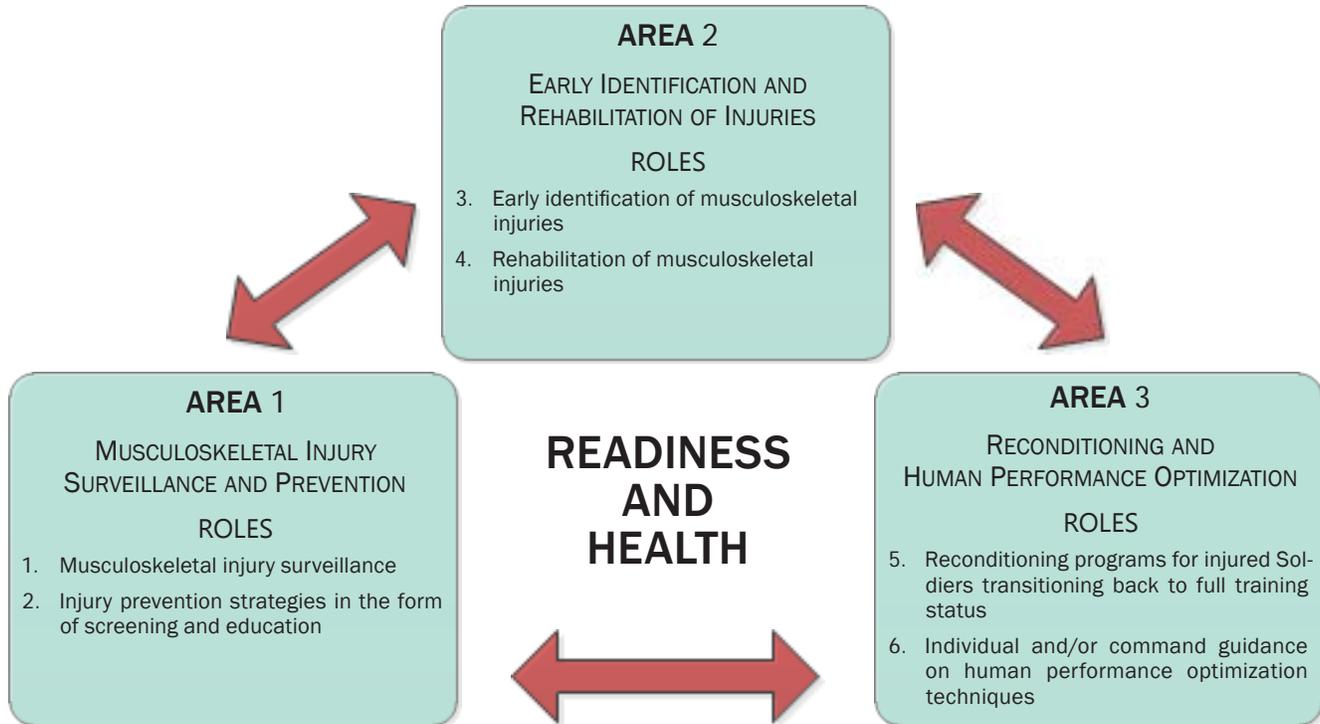
Musculoskeletal injuries (MSI) are the primary cause for healthcare visits, lost duty days, decreased readiness, medical evacuation, and disability in the military.¹⁻⁸ Musculoskeletal injuries resulted in 2.5 and 2.2 million healthcare visits in 2010 and 2012, respectively.^{2,3} Additionally, approximately 68,000 military members are injured on an annual basis, resulting in 25 million injury related lost duty days and healthcare costs exceeding \$700 million a year.^{4,5} The estimated annual salary cost alone for nondeployable Soldiers exceeds \$3 billion.⁵ The long-term costs of musculoskeletal disabilities are staggering with the Veterans Administration reporting annual compensation exceeding \$5.5 billion for service members with musculoskeletal disabilities.^{5,6} Musculoskeletal injuries during deployment are also extremely common with reports of 87% of all nonbattle injuries involving the musculoskeletal system.⁷ Further, nonbattle MSI was the leading cause of medical evacuations from theater from 2001 to 2010.⁷

ARMY PHYSICAL THERAPY PRIOR TO SEPTEMBER 2001

The roles and contributions of US Army physical therapists (PTs) have evolved since formal military physical therapy education and practice started in 1922. In particular, Army PTs have served in every major military conflict since World War II.⁸⁻¹⁰ Prior to the Vietnam War, Army PTs typically served in field or general hospitals

outside the combat zone (Level 4 care) or in large medical centers in the United States (Level 5 care) providing rehabilitative care. During Vietnam, the roles and responsibilities of Army PTs were expanded to include serving as physician extenders for the evaluation and treatment of neuromusculoskeletal conditions, with 43 Army PTs serving in 3 of 4 combat zones.^{8,9} Two key factors contributing to the use of Army PTs in a direct access role was the overwhelming MSI and orthopaedic surgical caseload during and following Vietnam.^{9,11-12}

Various studies prior to 2001 examined the impact of PTs in direct access and deployment settings.^{9,13-14} In particular, during Operation Desert Storm, return to duty rates for Soldiers evaluated by an Army PT were 90%.^{9,13} Research by Teyhen¹⁴ during peacekeeping operations in Bosnia reported that 19% of all patients seeking care at the combat support hospital (Level 3 care) were managed by physical therapy, with only 2% of all PT patients requiring lost duty, hospitalization, or medical evacuation. In 2000, Army PTs were assigned to Army Ranger battalions. The original PTs assigned to these units demonstrated immediate value for operational readiness and within a 10 month period, deployment readiness for Ranger Battalions shifted from 88% to 95%.^{9,13} The improvements in readiness were attributed to Ranger PTs focus on a Soldier sports medicine (SSM) model which defined 6 roles Army PTs, shown in the Figure, within the following 3 areas: (1) injury surveillance/prevention,



The Soldier Sports Medicine Model encompasses 6 key roles across 3 areas. All roles are interrelated and are a collaborated effort by the Soldier, command team, master fitness trainers, physical therapists, physical therapy technicians and medical staff is required to maximize readiness and Soldier health.

(2) early identification and rehabilitation of MSI, and (3) reconditioning/human performance optimization.⁹ The SSM approach using this concept continues to be the foundation of Army PT outpatient practice today, both in garrison and deployment.⁹

ARMY PHYSICAL THERAPY AFTER SEPTEMBER 2001

The growing evidence of Army PT's effect on readiness prior to September 2001, and the employment of the SSM model by US Army Rangers set the stage for expanded assignments and utilization of Army PTs during Operations Enduring Freedom and Iraqi Freedom (OEF/OIF). Specifically, Army PTs and enlisted physical therapy technicians started serving in US Special Operations Command (SOCOM) units and brigade combat teams (BCTs) in 2003 and 2005, respectively. During deployment, these assignments provided an immediate forward presence for Army PTs and PT technicians and allowed for an expansion of neuromusculoskeletal evaluation and treatment to Level 1 and 2 care facilities (forward operating base battalion aid stations).^{9,15} Army PTs serving in these assignments consistently traveled to Soldiers at various locations within their area of operation, thus reducing Soldiers' travel to a higher level of care at a combat support hospital (CSH).¹⁵ The combination of the number of MSI sustained during OEF/OIF, ill-defined enemy locations, and geographic separation

between operating bases also necessitated the augmentation of one to 2 additional physical therapists for each deployed CSH. Collectively, from 2001 to 2011, 162 Army PTs deployed in support of OEF/OIF,⁹ and in 2011, approximately 80% of all deployment qualified active duty Army PTs had deployed at least once.

CONTRIBUTIONS OF ARMY PHYSICAL THERAPY SINCE SEPTEMBER 2001

Early Identification and Management of Musculoskeletal Injuries

Since the beginning of the OEF/OIF conflict, Army PTs have embraced the SSM model and commitment to Soldier readiness. Research by Moore et al⁹ in 2013 provides descriptive data of patient encounters and management by deployed Army PTs from July 2004 to March 2011, presented in the Table. Findings from deployed BCTs and CSHs (N=74) reported that over one-third (38%) of all outpatient workload was completed by physical therapy with 45% of all physical therapy encounters being new evaluations. Additionally, almost half (45%) of new evaluations were seen on a direct access basis with CSH specific data confirming that 91% of military personnel with MSI at Level 3 care were managed by physical therapy. Overall, the low ratio of new evaluations to overall visits (71,310/157,337; 1 new evaluation per 2.3 overall encounters) suggests most military personnel required

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minimal visits and almost all (97%) were returned mission capable.⁹

Moore et al⁹ also examined CSH and BCT data in isolation, and of the 71,310 BCT/CSH PT new evaluations reported, 69% (48,879) were evaluated by PTs serving in BCTs. These findings emphasize the forward shift of Army PTs and reflect that the majority of physical therapy patients were managed by PTs organic to the brigade. In consultation with brigade physician assistants, it was also reported that 31% (15,084/48,879) of patients seen by BCT PTs would have required evacuation to the CSH had a PT not been assigned to the brigade. Combat support hospital physicians also reviewed physical therapy new evaluations and determined that 18% of patients seen by CSH PTs would have been evacuated from theater had a PT not been present. Collectively, these findings suggest that Army PTs serving as part of the CSH or BCT healthcare teams during OEF/OIF diagnosed and treated a significant percentage of MSIs, maintained readiness, and minimized evacuation for additional care.^{9,15}

A survey of primary care BCT healthcare providers (N=107) also reported BCT PTs significantly decreased medical evacuations within (68%) and out of theater (73%). Brigade providers also felt that PTs positively affected the overall mission (97%), patient prognosis (83%), and PTs were considered the local expert in musculoskeletal pathology (92%), including radiology (79%).¹⁶ The clinical diagnostic accuracy of military PTs as compared to magnetic resonance imaging has also been assessed among military PTs, orthopaedic surgeons, and nonorthopaedic healthcare providers. Findings demonstrated that the diagnostic accuracy for military PTs and orthopaedic surgeons was superior to nonorthopaedic providers.¹⁷ Finally, the safety of direct access military physical therapy care was evaluated across 25 DoD healthcare sites and involved 112,653 new patient evaluations with 50,799 (45%) of the patients seen through direct access without physician referral. Over the 40-month data collection period, there were no reported or documented adverse events, probation or reduction of privileges, state licensure disciplinary actions, or litigation cases involving DoD credentialed PTs.¹⁸ United States military PTs in garrison and during deployment are deemed by their counterparts to provide safe and critical expertise with regards to the prevention, diagnosis, and management of musculoskeletal conditions. Serving in a direct access role to identify and manage

Data Comparing Outpatient Physical Therapy Encounters From Combat Support Hospital and Brigade Combat Teams During Operation Iraqi Freedom/Operation Enduring Freedom From July 2004 to March 2011.

Description of Workload	Outpatient Encounters	Percentage of Total
Physical therapy encounters/total of patient encounters for organization (CSH/BCT)	157,337/416,987	37.7
Physical therapy new evaluations/physical therapy total encounters (CSH/BCT)	71,310/157,337	45.3
Direct access evaluations/total physical therapy evaluations (CSH/BCT)	31,769/71,310	44.6
Musculoskeletal injuries managed by PTs compared with other providers (CSH only)	34,009/37,332	91.1
Soldiers returned to duty treated by physical therapists/total physical therapy evaluations (CSH/BCT)	69,454/71,310	97.4
CSH Soldiers who would have required theatre evacuation had a PT not been present (CSH only)	3,979/22,431	17.7
BCT Soldiers requiring evacuation to a CSH or out of theatre had a PT not been present (BCT only)	15,084/48,879	30.9

Data are from Moore et al.⁹
CSH indicates combat support hospital; BCT, brigade combat team; PT, physical therapist.

musculoskeletal conditions appears to enhance physical therapy care closer to the point and time of injury while allowing other members of the healthcare team to focus on complex medical and surgical patients sustaining traumatic injuries.

Musculoskeletal Injury Surveillance

A concentrated effort was made by Army PTs during OEF/OIF to conduct MSI surveillance with a specific focus on body regions involved and mechanisms of injury.⁹ Three separate physical therapy studies examining MSI injuries by body region have consistently demonstrated the top 5 involved regions as lumbar spine, knee, leg/foot/ankle, shoulder, and cervical spine.^{9,19,20} Research by Roy et al^{19,20} also reported on occupational and gender differences for body regions and mechanisms of injuries for deployed BCT Soldiers. The authors identified that female Soldiers deployed in support of OEF had a higher percentage of lower extremity (women: foot/ankle=22%, knee=17%, hip=11%; men: foot/ankle=19%, knee=8%, hip=1%) injuries as compared to male Soldiers who sustained higher rates of low back injuries (men=32%; women=22%).¹⁹ Roy²⁰ also demonstrated variability in body region injured, diagnosis, and mechanism of injury based on occupational specialty and authors emphasized a need for specific occupational injury prevention strategies.

Injury Prevention, Reconditioning, and Human Performance Optimization

Since 2008, Army PTs have led a DoD funded project examining military power, performance, and injury prevention.²¹⁻²³ This trial involved injury prevention (IP) and physical performance screening of over 1,400 US

Army Rangers, special operations and BCT Soldiers. To date this research has outlined advances in musculoskeletal screening, provided normative data for various physical performance screening measures, and identified multiple potential predictors of MSI sustained by US Army Rangers.²¹⁻²³ Additional research is required to refine MSI screening for the Army but this area holds great potential for mitigating injuries and optimizing readiness.

The contribution of Army PTs to IP, reconditioning, and human performance optimization (HPO) efforts in response to OEF/OIF are also highlighted by collaborative efforts with the US Army Fitness Institute, Public Health Command, US Army Research Institute of Environmental Medicine, and the Office of the Army Surgeon General. In particular, these collaborative efforts led to injury prevention programs in initial entry training that resulted in decreased femoral neck stress fractures, integration of physical readiness training, reconditioning programs, and recommendations for pre-enlistment physical performance screening.^{24,25} Additional research by Lester et al²⁶ was also integral for defining the impact of deployment on BCT Soldiers' body composition and physical fitness and the potential importance of additional targeted HPO physical training postdeployment. The importance of high intensity reconditioning or "bridge program to return to duty" was also demonstrated by an Army PT serving with SOCOM. Following rehabilitation, Soldiers who completed a 6-week functional training program exhibited statistically significant pre- to posttraining improvements in agility, vertical jump height, timed and distance hop testing, kip-ups, and body fat.²⁷ Although promising, additional research examining the effect of reconditioning programs on injury prevention, Soldier specific occupational tasks, and readiness are needed.

ARMY PHYSICAL THERAPY LESSONS LEARNED

It is important to point out that for this article the focus was limited to Army PTs' impact on the surveillance, prevention, early assessment, rehabilitation, and reconditioning of MSI in an outpatient setting. This manuscript does not address the countless contributions Army physical therapy has provided in the areas of polytrauma, amputee, limb salvage, burn and neurologic (eg, traumatic brain injury, spinal cord injury, vestibular dysfunction) rehabilitation during OIF/OEF. A systematic review of the affect that Army PTs had on these conditions and lessons learned is warranted.

With regard to MSI, the opportunities, contributions, and lessons learned by US Army Physical Therapy since 2001 are numerous and diverse. First, Army PTs

were integral to the early identification and management of MSIs during OEF/OIF, and PTs directly contributed to maintaining Soldier readiness and decreased medical evacuations within and outside the theater of operations.⁹ Second, despite the expansion of Army PTs into the BCTs, full integration of a SSM model, and specifically, adequate resources (currently 1 PT/1 PT enlisted per 3,500 BCT Soldiers) to address the IP, reconditioning, and HPO roles remain a challenge. Future BCT PT staffing models similar to those in Ranger and SOCOM units (1 PT and 1 PT technician per 600-1000 personnel) would allow Army PTs to address the IP, reconditioning, and HPO needs of BCT Soldiers. The third lesson learned involves a need for continued development, standardization, and policy/leadership support for physical training, reconditioning, and employment of an annual musculoskeletal physical performance screening assessment.^{5,21} It is also important that the selected screening measure(s) and reconditioning/HPO programs nest with critical occupational and physical readiness tasks.^{5,21} Improvements in these areas will require continued collaboration with multiple organizations, but ultimately hold great potential for maximizing readiness and the health of the force. Additional support for physical therapy clinical outcomes research, including integration within the electronic health record, is critical for analyzing current practice and optimizing care. Military physical therapy is a leader within evidence-based physical therapy practice, as demonstrated by over 400 military PT publications since 2001.²⁸ Finally, Army physical therapy's success has developed since 1922 secondary to a long-standing commitment to education/training across the career lifespan of officers, enlisted, and civilian PT team members. Since 2001, Army physical therapy has expanded entry-level physical therapy education to the doctoral level, established 2 doctor of clinical sciences fellowships (sports medicine and orthopaedic manual therapy), developed 2 postprofessional short courses (joint operational deployment course and forward musculoskeletal screening course), integrated a military physical therapy residency, and expanded educational opportunities for PhD and training with industry. Future commitment to these programs and expansion of enlisted and civilian training are required to enhance the health and readiness of the future force.

REFERENCES

1. Hauret KG, Jones BH, Bullock SH, Canham-Chervak M, Canada S. Musculoskeletal injuries description of an under-recognized injury problem among military personnel. *Am J Prev Med.* 2010;38(1 suppl):S61-S70.

PERSONNEL CHANGES THAT IMPACTED CARE AND OUTCOMES

2. Ambulatory visits among members of the active component, U.S. Armed Forces, 2010. *MSMR*. 2010;18:16-21.
3. Army Medical Surveillance Activity. Absolute and relative morbidity burdens attributable to various illnesses and injuries, U.S. Armed Forces, 2012. *MSMR*. 2013;20:5-10.
4. Ruscio BA, Jones BH, Bullock SH, et al. A process to identify military injury prevention priorities based on injury type and limited duty days. *Am J Prev Med*. 2010;38(suppl 1):S19-S33.
5. Nindl BC, Williams TJ, Deuster PA, Butler NL, Jones BH. Strategies for optimizing military physical readiness and preventing musculoskeletal injuries in the 21st century. *US Army Med Dep J*. October-December 2013:5-23.
6. Gilchrist J, Jones BH, Sleet DA, Kimsey CD. Exercise-related injuries among women: strategies for prevention from civilian and military studies. *MMWR Recomm Rep*. 2000;49(RR-2):15-33.
7. Armed Forces Health Surveillance Center (AFHSC). Causes of medical evacuations from Operations Iraqi Freedom (OIF), New Dawn (OND) and Enduring Freedom (OEF), active and reserve components, U.S. Armed Forces, October 2001-September 2010. *MSMR*. 2011;18(2):2-7.
8. Hartwick AMR. *The Army Medical Specialist Corps*. Washington, DC: US Army Center of Military History; 1993.
9. Moore JH, Goffar SL, Teyhen DS, Pendergrass TL, Childs JD, Ficke JR. The role of U.S. military physical therapists during recent combat campaigns. *Phys Ther*. 2013;93:1268-1275.
10. Benson CJ, Schreck RC, Underwood FB, Greathouse DG. The role of Army physical therapists as nonphysician health care providers who prescribe certain medications: observations and experiences. *Phys Ther*. 1995;75:380-386.
11. Greathouse DG, Schreck RC, Benson CJ. The United States Army physical therapy experience: evaluation and treatment of patients with neuromusculoskeletal disorders. *J Orthop Sports Phys Ther*. 1994;19(5):261-266.
12. *Army Regulation 40-68: Clinical Quality Management*. Washington, DC: US Department of the Army; 2004 (revised 2009).
13. Garber MB, Baxter RE. Physical therapy in the US Army combat health support system. A research paper presented to the US Army Command and General Staff College in partial fulfillment of the requirements for A462: Combat Health Support Seminar; 2003; Fort Leavenworth, KS.
14. Teyhen DS. Physical therapy in a peacekeeping operation: Operation Joint Endeavor/Operation Joint Guard. *Mil Med*. 1999;164(8):590-594.
15. Rhon DI. A physical therapist experience, observation, and practice with an infantry brigade combat team in support of Operation Iraqi Freedom. *Mil Med*. 2010;175:442-447.
16. Rhon DI, Gill N, Teyhen D, Scherer M, Goffar S. Clinician perception of the impact of deployed physical therapists as physician extenders in a combat environment. *Mil Med*. 2010;175:305-312.
17. Moore JH, Goss DL, Baxter RE, DeBerardino TM, Mansfield LT, Fellows DW, Taylor DC. Clinical diagnostic accuracy and magnetic resonance imaging of patients referred by physical therapists, orthopaedic surgeons, and nonorthopaedic providers. *J Orthop Sports Phys Ther*. 2005;35:67-71.
18. Moore JH, McMillian DJ, Rosenthal MD, Weishaar MD. Risk determination for patients with direct access to physical therapy in military health care facilities. *J Orthop Sports Phys Ther*. 2005;35:674-678.
19. Roy TC, Ritland BM, Sharp MA. A description of injuries in men and women while serving in Afghanistan. *Mil Med*. 2015;180:126-131.
20. Roy TC. Diagnoses and mechanisms of musculoskeletal injuries in an infantry brigade combat team deployed to Afghanistan evaluated by the brigade physical therapist. *Mil Med*. 2011;176:903-908.
21. Teyhen DS, Shaffer SW, Umlauf JA, et al. Automation to improve efficiency of field expedient injury prediction screening. *J Strength Cond Res*. 2012;26(suppl 2):S61-S72.
22. Teyhen DS, Shaffer SW, Butler RJ, et al. What risk factors are associated with musculoskeletal injury in US Army Rangers? A prospective prognostic study. *Clin Orthop Relat Res*. 2015;473:2948-3958.
23. Teyhen DS, Riebel MA, McArthur DR, et al. Normative data and the influence of age and gender on power, balance, flexibility, and functional movement in healthy service members. *Mil Med*. 2014;179:413-420.
24. Scott SJ, Feltwell DN, Knapik JJ, Barkley CB, Hauret KG, Bullock SH, Evans RK. A multiple intervention strategy for reducing femoral neck stress injuries and other serious overuse injuries in U.S. Army Basic Combat Training. *Mil Med*. 2012;177:1081-1089.
25. Molloy JM, Feltwell DN, Scott SJ, Niebuhr DW. Physical training injuries and interventions for military recruits. *Mil Med*. 2012;177:553-558.
26. Lester ME, Knapik JJ, Catrambone D, Antczak A, Sharp MA, Burrell L, Darakjy S. Effect of a 13-month deployment to Iraq on physical fitness and body composition. *Mil Med*. 2010;175:417-423.

THE ARMY MEDICAL DEPARTMENT JOURNAL

27. Goss DL, Christopher GE, Faulk RT, Moore J. Functional training program bridges rehabilitation and return to duty. *J Spec Oper Med.* 2009;9:29-48.
 28. Published Research Articles. The US Army Baylor University Doctoral Program in Physical Therapy Web Site. Available at: <http://www.baylor.edu/graduate/pt/index.php?id=34391>. Accessed October 1, 2015.
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The Role of Army Nurse Practitioners Supporting Wars in Iraq and Afghanistan

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ABSTRACT

Family nurse practitioners are an essential member of the military medical team. They were incorporated into the Army medical system almost as soon as there was an academic program to develop the role in primary care settings. The role for nurse practitioners during deployment has not been as clear. Even though they have been around for 50 years, the specific role nurse practitioners provide is still evolving. This article explores the incorporation of nurse practitioners into Army medicine with a focus on deployed medicine. Nurse practitioners have been shown to be very versatile providers with the requisite skill sets to meet the demands of the combat environment and are able to substitute for other medical assets that are critically short due to sustained conflict. Clarifying the value a nurse practitioner brings to medical care in the combat environment is essential to insure all assets are being employed to provide the best medical care to the US fighting force.

In 2015, Army nurse practitioners celebrate 50 years of providing high-quality, patient-centered primary and specialty care as part of the military medical team.¹ Over this time, facility-based Army nurse practitioners have seen a gradual yet steady increase in roles and responsibilities. Today, nurse practitioners in non-deployed settings enjoy a predominantly autonomous practice with a clearly delineated role in caring for patients within patient centered medical homes. In fact, the Army has been granted a special waiver by the National Committee for Quality Assurance to allow Army nurse practitioners to be patient-centered medical home team leaders. Within the military medical system, the combat mission remains paramount. While the role of nurse practitioners in nondeployed settings has matured, the “go to war” roles for them have expanded at a slower pace. This article explores the maturing role for the nurse practitioner in Army medicine.

EVOLVING ROLES FOR THE NURSE PRACTITIONER

The nurse practitioner role has evolved differently between the peacetime and wartime missions. The Army was quick to incorporate nurse practitioners into medical care being provided within the United States. The first advanced practice nurses in primary care, called nurse clinicians in ambulatory care, were recognized in June 1972¹ and assigned to select military medical facilities.² This was very progressive as the first nurse practitioner academic program had begun only 7 years previously and the American Nurses Association would not establish the Council of Primary Care Nurse Practitioners until 1974.³ Nurse practitioners were incorporated into the Army Medical Department, growing and

expanding in role and scope of practice. Today, over 170 family nurse practitioners (FNPs) serve on active duty in the Army.

The evolution of the role of FNPs during deployment or combat has been less methodical. The reasons are unclear but may be due in part to the relatively recent introduction of nurse practitioners into the combat environment. Incorporating a new nursing specialty into the go-to-war mission requires both a clear need and display of essential skills to meet that need. While the role of Army nurse practitioners in noncombat positions has become an integral part of normal patient care, the opportunity to explore the role in combat has been limited until very recently. Combat action in Vietnam concluded in 1975, only 3 years after FNPs were introduced into the Army, which did not allow time to evaluate the role of nurse practitioners in that conflict. Between 1975 and 1990 there were several minor combat deployments to Grenada and Panama. These conflicts were brief and did not strain the medical system, resulting in little interest in changing the accepted models of care. The first major troop deployment that required full fielding of all medical assets occurred with the advent of Desert Shield/Desert Storm in 1990. A number of nurse practitioners were deployed with the rest of the medical assets. The exact number is unknown because there existed no specified combat role for an Army nurse practitioner nor institutional method to track them during a deployment. These nurse practitioners were unrecognized in the Professional Filler System (PROFIS) and subsequently deployed into combat hospital nursing specialties of medical/surgical, emergency, or critical care nursing. Despite

this limitation, a select few nurse practitioners were able to make their debut in this conflict. These nurse practitioners self-identified as providers to their respective units once deployed. As nurse practitioners were an integral part of patient care in CONUS, the skills they were offering were known to the leadership. The nurse practitioners were given permission to become credentialed providers in theater. However, the decision remained on a case-by-case basis handled at the unit level.

The recognition of a role for nurse practitioners in a combat environment led to a broader discussion of how to institutionalize the role. However, Desert Shield/Desert Storm also ended quickly with the medical system having sufficient medical resources to meet the demand. This short combat action was followed by a rapid redeployment back to the United States which once again relegated consideration of the role of nurse practitioners in the combat environment into an academic discussion with no clear answers.

The commencement of protracted combat operations in Afghanistan and Iraq taxed the Army medical system in terms of the length and frequency of deployments for healthcare providers. As a result of the high operational tempo with resultant strain from frequent deployments on physicians and physician assistants, nurse practitioners were once again evaluated for a permanent role on the Table of Organization and Equipment* (TO&E).

THE EMERGENCE OF ARMY FNPs DURING OPERATIONS IN IRAQ AND AFGHANISTAN

In 2001, the United States entered into a series of conflicts which have lasted over a decade. At the commencement of hostilities, troops and medical assets were deployed into Afghanistan using the same medical deployment model employed in Desert Storm. Deployed FNPs once again found themselves working in traditional roles such as staff nurses on medical-surgical wards or using previously acquired skills in specialty areas such as critical care or emergency nursing. There were, however, some indications that FNPs were beginning to be recognized in theater. In 2003, the 28th Combat Support Hospital (CSH) was deployed to Iraq with a complement of nurses that included nurse practitioners. While awaiting movement orders into Iraq, it became evident that medical support was significantly limited at a staging base located in Kuwait. Two nurse practitioners from the 28th CSH were selected to lead the mission of establishing a troop medical clinic. Through close coordination with the leadership of the 28th CSH and 21st CSH, the nurse practitioners garnered the appropriate

approvals to allow nurse practitioners to provide primary care within the newly established Troop Medical Clinic at Camp Victory, Kuwait. The clinic employed 8 nurse practitioners and other members of the healthcare team who successfully provided round-the-clock care for over a month to an estimated 1,956 service members that presented with a wide variety of disease and non-battle injuries.⁴

As the conflicts intensified, the need to officially recognize the role and combat functionality for nurse practitioners grew. The FNP Consultant to The Surgeon General began to push for recognition of FNPs prior to deployment in order to assign them to provider roles as well as maintain visibility of where the FNPs worked and to which units they were assigned within the theater of operations. This effort met with success in 2004 when the first official FNP TO&E slot was approved within a combat support hospital. Assignment to a hospital unit represents the most direct translation of an FNP's skills between nondeployed hospitals in the United States to deployed hospitals in a combat zone. Notably, the broad utility of the FNP skill set offered many other avenues for FNPs in the combat environment. At the beginning of 2005, 6 nurse practitioners were specifically designated to deploy as FNPs, but with dramatically different roles. Four deployed to function as general practitioners conducting routine patient care in the rear echelon. They were assigned with family practice physicians to conduct routine sick call as well as physicals for troops headed to theater. The 2 others, however, were sent to act as medical advisors to the Multinational Security Transition Command–Iraq. The 2 FNPs embedded within Iraqi military units in order to teach them how to provide medical care. Perhaps due to the success of these 2 individuals or perhaps just a recognition of the versatility of the FNP skill set, FNPs were soon being considered to assist with other critical shortages being seen in theater. The pool of forward deployed physician assistants in battalion aid stations became strained due to the continued high operational tempo and relatively limited supply of physician assistants available for deployments. Having similar skill sets and more availability, nurse practitioners began to be substituted for a select number of physician assistant positions. These substitutions were soon followed by nurse practitioners also being employed to fill vacant slots for a family physician in the combat support hospital (W. Bester, oral communication, January 22, 2011) and to replace a physician in the 549th Area Support Medical Company.⁴ The continued integration of FNPs into combat continued to evolve slowly with nurse practitioners substituting for physicians and physician assistants as shown in the Table. However, 2 years after the policy changes

*A Table of Organization and Equipment defines the structure and equipment for a military organization or unit.

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were made and 7 years after initiation of combat action, 25% of deploying nurse practitioners were still being assigned to noncredentialed nursing positions.⁵

THE ROLE OF FNPs IN A COMBAT ENVIRONMENT

As the wars in Iraq and Afghanistan are drawing to a close, the role for the family nurse practitioner in a combat support hospital has been validated. While this seems a simple translation of current peacetime FNP utilization into a combat environment, recent literature would suggest that the skills may not be entirely similar.

Lewis et al⁶ surveyed 50 Army FNPs with deployment experience to elucidate their clinical practices while deployed. Only two-thirds (62%) of the nurse practitioners reported clinical care as their primary duty with various other leadership positions accounting for the other third. Those in clinical care saw typical primary care complaints such as musculoskeletal complaints, back pain, gastrointestinal issues and psychiatric issues. These FNPs practiced independently with over 80% reporting a need to collaborate with a physician “only occasionally” or “not at all.” Interestingly, 44% of the nurse practitioners surveyed reported having credentials to admit to observational hold status and 12% having full hospital admission privileges.

While the FNP’s practice seemed to be traditional in many respects, there are some indications that many also experienced a practice which was more intense than that seen in peacetime when practicing outside the primary care setting. One study (R. M. P., unpublished data, 2012) found that 47.8% of surveyed FNPs reported independently assessing trauma and 30.4% reported independently managing trauma. According to Lewis et al,⁶ about 20% of surveyed FNPs reported participating in combat patrols, 68% reported coming under direct or indirect fire, and 24% report encountering improvised explosive devices or land mines. Currently, there is limited research on the evolving role for the FNP in combat.

CONCLUSION

The wars in Iraq and Afghanistan are the first conflicts in US history that have officially recognized the role of the deployed nurse practitioner. At the commencement of hostilities in 2001, nurse practitioners were deployed in a range of roles from bedside medical surgical nurses to advanced practice nurses. In 2005, the Army Medical Department officially recognized that FNPs are force

multipliers and possess the requisite skills and scope of practice to accomplish the mission. Over the course of 14 years of conflict, nurse practitioners have become vital members of deployed medical teams with expanded roles and responsibilities.

In 2012, The Surgeon General of the Army commissioned a RAND Corporation study⁷ that explored methods to improve the Army’s deployment augmentation system (PROFIS) to find ways of ensuring that health-care needs are efficiently met both in garrison and on the battlefield. One of the recommendations was to improve the utilization of nurse practitioners and physician’s assistants in direct support of maneuver units. A revision in the military regulations governing nurse practitioner practice will be required to fully implement that recommendation. Credentialing for nurse practitioners is delineated within *Army Regulation 40-68*.⁸ There is ambiguity within the regulation regarding the authority of a nurse practitioner to delegate medical tasks such as administration of controlled substances to unlicensed personnel (for example, medics). This authority is seen

as critical in a war environment. If nurse practitioners are deployed to level I echelon of care, such authority is necessary to allow medics to perform the duties they have been assigned in a combat environment.

There are many anecdotal stories regarding the exceptional performance of nurse practitioners who have been deployed to various clinical and leadership positions during the wars in Iraq and Afghanistan. Unfortunately, there is little scientific research investigating the roles of nurse practitioners during deployments. Conflicts are cyclical and it is expected that, at some point in the future, the US Army will once again be called upon to protect our nation. The Army Medical Department will be ready and able to care for the sick and wounded. As the history of the conflicts in Operations Enduring Freedom and Iraqi Freedom are written, the effect of nurse practitioners on the provision of battlefield healthcare will become more apparent. Leveraging the capability and capacity of all members of the healthcare team is of paramount importance in a time of diffuse threats and diminishing medical resources.

Roles of US Army Family Nurse Practitioners During Deployments to Combat Theaters, 2003-2015.

Role	AOC	Number Performing Role
Family Nurse Practitioner	66P	133
Physician Assistant	65D	54
Family Medicine Physician	61H	18

AOC indicates Area of Concentration, the alphanumeric designator of the medical specialty.

REFERENCES

1. Sarnecky MT. *A Contemporary History of the U.S. Army Nurse Corps*. Fort Sam Houston, Texas: The Borden Institute; 2010.

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2. Sarnecky MT. *A History of the U.S. Army Nurse Corps*. Philadelphia, PA: University of Pennsylvania Press; 2004.
3. American Association of Nurse Practitioners. Historical Timeline [internet]. Available at: <https://www.aanp.org/about-aanp/historical-timeline>. Accessed November 30, 2015.
4. Dargis J, Horne T, Tillman-Ortiz S, Scherr D, Yackel EE. Expanding the role of the nurse practitioner in the deployed setting. *Mil Med*. 2006;171(8):770-773.
5. Franklin BE, Carr KV, Padden DL. Self-assessment of trauma competencies among army family nurse practitioners. *Mil Med*. 2008;173(8):759-764.
6. Lewis PC, Stewart D, Brown W. Deployment experiences of Army nurse practitioners. *Mil Med*. 2012;177(8):889-893.
7. Sobero ME, Olmsted SS, Morganti KG, Burns RM, Haas AC, Biever K. *Improving the Deployment of Army Health Care Professionals: An Evaluation of PROFIS*. Santa Monica, CA: RAND Corporation; 2013. Technical Report TR-1227-A. Available at: http://www.rand.org/pubs/technical_reports/TR1227.html. Accessed November 30, 2015.
8. *Army Regulation 40-68: Clinical Quality Management*. Washington, DC: US Department of the Army; 2004 [revised 2009];29. Available at: http://www.apd.army.mil/pdffiles/r40_68.pdf. Accessed November 30, 2015.

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Advances in Anesthesia Delivery in the Deployed Setting

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ABSTRACT

Lessons learned over the past decade and a half of combat casualty management has brought about numerous advances in trauma anesthesia practice. In the post-Vietnam era, deployable anesthesia equipment centered on the capability to provide a balanced anesthetic technique, utilizing a combination of volatile gas and intravenous anesthetic adjuncts. The evolution of the modern battlefield has forced anesthesia providers across the military to adapt to mission requirements that often dictate a surgical capability that is more rapidly mobile and less reliant on logistical support. Institutional medical equipment development has focused on fielding a lighter, more mobile volatile gas delivery method. Despite numerous advances in anesthetic gas delivery, many veteran anesthesia providers have come to recognize the value of alternative anesthetic techniques in the deployed setting. One of the most appealing advances in combat anesthesia practice is the emergence of total intravenous anesthetics (TIVA) for trauma management and resuscitation. Although there have been numerous developments in anesthetic equipment for use in the deployed setting, TIVA has many advantages over volatile gas administration. Future research, development, and education should focus on TIVA and the ability to provide this as an alternative safe anesthetic for patients in austere environments. It is imperative to retain the lessons we have learned in order to adapt more effectively in future conflicts. This accumulation of knowledge must inform future innovative solutions to the challenges of casualty management in a deployed setting.

In August 2015, the Chief of Staff of the Army, GEN Mark A. Milley, emphasized the importance of listening and learning from the Army itself and preparing for the fight tomorrow. It is imperative to capture the lessons learned from the current conflict while the subject matter experts are still able to provide the necessary feedback to implement change. Preparation for future conflict is replete with new and innovative ideas, however, these initiatives should be informed by listening to previous lessons learned. The determination of anesthetic capability begins prior to any patient ever showing up on an operating table. The anesthesia provider, as part of a medical planning team, is key to any successful deployment or humanitarian mission. A working knowledge of the number of personnel supported, expected casualties rate, and logistical support available to the surgical team will always influence the anesthesia plan that can be sustained. For example, some supported units may have insufficient lift or ground capability to move a fully manned and equipped surgical team. This places a limitation on the mobility of the surgical team unless they are able to reduce their weight and cubic requirements. These limitations directly affect the type of anesthetic that a forward deployed provider can deliver. Although there have been numerous developments in volatile anesthesia equipment for the deployed setting, total intravenous anesthesia (TIVA) has emerged as a safe alternative with additional physiologic advantages. Ideally, the optimal anesthetic kit for any mission is

based on durability, dependability, weight, and volume. An anesthetic packing plan centered on a TIVA capability fulfills these requirements.

DEPLOYABLE ANESTHESIA EQUIPMENT

The evolution of mission requirements and the fluid nature of the battlefield has directed surgical and advanced resuscitation capability to move increasingly forward. Often located within minutes of the point of injury, surgical teams are frequently deployed in elements smaller than the traditional Role 2 forward surgical team. Military anesthesia providers have consistently sought to find the optimal anesthesia equipment set to meet mission requirements, increase mobility, and still maintain the highest standard of anesthetic care. The traditional combat anesthetic is a balanced technique of volatile inhalation gas and intravenous anesthetic adjuncts. In the early phases of Operation Enduring Freedom and Operation Iraqi Freedom, many anesthesia providers deployed with the Ohmeda Universal Portable Anesthesia Complete (PAC) draw-over anesthesia system to deliver volatile inhalation anesthetics. The draw-over meets the requirements discussed above. Since its development in the 1970s, the PAC has proven to be durable, dependable, and relatively lightweight. Additionally, it does not require power or gas flow to deliver an anesthetic. However, the draw-over does have limitations, which include the requirement to scavenge waste gases and the potential, as with all volatile gases, to trigger malignant hyperthermia,

a potentially lethal metabolic crisis in susceptible individual. Perhaps the greatest barrier to the continued use of this device is that it is no longer being manufactured by Ohmeda and no commercial vendor has offered a replacement; meanwhile, stockpiles of replacement parts are rapidly being depleted. A similar problem occurred with the Narkomed M anesthesia machine (Drägerwerk AG, Lübeck, Germany) secondary to the manufacturer discontinuing its production. The device was simple and safe and similar in design to anesthesia machines familiar to providers used in the United States. Unfortunately, the Narkomed M failed to meet the criteria for agile surgical teams on many levels. First, the machine and its components weigh close to 200 pounds. Secondly, it requires compressed gas and power for sustained operations. Consequently, the Narkomed M was limited to use by Role 2 (forward surgical team) and Role 3 (combat support hospital/field hospital) medical facilities.

In response to continued requirements for a suitable field anesthesia machine, the Defense Medical Standardization Board convened a Theater Care Anesthesia Working Group to evaluate commercial, off the shelf, anesthesia machines suitable for use in austere environments. The purpose was to quickly field a unit that would replace the Narkomed M while maintaining the standards for safety and mobility. The recommendation forwarded was the Dräger Fabius Tiro M. The most noticeable differences from the Narkomed M was that the Tiro M provided alternative ventilation modes and integrated safety features absent in earlier generations of field anesthesia machines. The familiar technology provided by the Trio M appealed to most anesthesia providers, however, once again this device was designed for Role 2 and higher medical facilities with limited requirements for mobility. The newly fielded Tiro M weighs 200 pounds, has regular maintenance requirements, and requires electrical power to operate the ventilator (battery charge limited to 45 minutes.) There are similar limitations found with the Magellan anesthesia machine. Although it weighs only 45 pounds, which makes it more appealing for field anesthesia, the protective case required for transport adds an additional 65 pounds. As with all other volatile gas machines, this makes the Magellan suitable for Role 2 medical facilities but not practical for mobile surgical teams with weight and cubic restrictions. For these reasons, TIVA, rather than volatile gas anesthetics, may be a more desirable method for providing anesthesia in deployed mobile surgical teams.

OXYGEN CONCENTRATORS

The development and implementation of commercially available oxygen concentrators have reduced many of the requirements to maintain large quantities of

compressed gas. All commercially available anesthetic machines, however, require a compressed gas source. Most mobile surgical units deploy with E size compressed gas cylinders, which weigh on average 8 pounds empty. Some Role 2 (forward surgical team) facilities deploy with H size compressed gas cylinders, which are over 100 pounds each. The use of compressed gas by surgical teams can create a burdensome logistical problem by introducing the requirement for a robust infrastructure with capability to refill and procure replacement cylinders. In some cases, a local vendor may be available, however, a quality control issue is introduced when relying on an outside source.

Patient air and ground transport add an additional consideration when using compressed gas. A traditional alloy-encased bottle may become compromised and suffer catastrophic failure. The explosive release of metal fragments can create safety concerns for air and ground crew personnel.¹ Consequently; the use of Kevlar oxygen bottles has gained support for long distance transport. Kevlar is approximately half the weight of an ordinary, alloy-encased oxygen cylinder. Additionally, the Kevlar casing may help reduce ductile failure, limiting cylinder disintegration and the risk of fragmentation if compromised.¹ However, the unacceptable risk of fragmentation remained, especially for patient transport via aircraft. In an effort to reduce reliance on compressed gas, US Army Medical Department leadership invested in systems that actually generate oxygen through room air concentration at the point of use. This initiative ensured that the supply of oxygen was uninterrupted on the battlefield.² Portable oxygen concentrators were subsequently developed, including the Eclipse and Saros (Sequal Technologies, Ltd, Taipei City, Taiwan). The implementation of oxygen concentrators resolved several problems created by compressed gas cylinders. First and foremost, they clearly reduced explosive risk and personnel endangerment. Secondly, they reduced or eliminated logistical requirements incumbent with the use of compressed oxygen cylinders. Finally, the concentrators that have been fielded have demonstrated their ability to remain functional in extreme temperatures and harsh environments, which make them a perfect complement for TIVA administration.

TOTAL INTRAVENOUS ANESTHESIA

The technique or specific drugs used when designing an anesthesia plan for a trauma patient may often appear irrelevant.³ Experienced providers argue that the best results are achieved by familiarity and experience of the anesthetist. Based on the modality of administration, anesthetics agents can be divided into 2 subclasses: those delivered by inhalation via volatile gases and

those delivered intravenously (TIVA).³ Whether using TIVA or inhalation, either technique must be carefully titrated to the hemodynamic profile while assuring adequate sedation/hypnosis and analgesia.⁴ Unfortunately, in some percentage of patients it is nearly impossible in early resuscitation efforts to adequately address all pillars of anesthesia while maintaining hemodynamic stability. Total intravenous anesthesia provides the anesthesiologist with a unique flexibility. The provider can select individual intravenous agents and concentrations that address analgesia, amnesia, and akinesia with reduced detriment to the patient's hemodynamic stability.

Historically, a typical trauma anesthetic may have been accomplished using 2 simple intravenous medications, scopolamine and a narcotic. However, in the past year, the manufacture of intravenous scopolamine has become very limited leaving anesthesia providers in search of alternative agents for trauma patients in extremis. Intravenous anesthetic management of the trauma patient is still preferred over volatile anesthetic management for emergent airway facilitation and damage control surgery. There are several alternative intravenous agents that have been implemented with varied success. Intravenous medications such as propofol, etomidate, midazolam, and fentanyl have been administered alone and in combination for induction and anesthetic maintenance during trauma resuscitation. One of the most promising intravenous anesthetic agents for trauma is ketamine, an older medication that was previously avoided because of undesired side effects. However, as the clinical management of ketamine administration improves and renewed research provides refutable evidence from previous claims, anesthesia providers have taken a second look at ketamine use in trauma.⁵ In fact, some evidence suggests that ketamine may provide a neuroprotective quality by improving cerebral perfusion in neurologic injury.⁶

A number of studies have compared TIVA and volatile anesthetics. The results demonstrated in Englehart et al showed that a TIVA regimen produced less pronounced hypotension than isoflurane in uncontrolled hemorrhagic shock.⁶ The study suggested that in circumstances of limited resources, such as mobile surgical teams, a ketamine-based TIVA regimen might be a viable option. Ketamine is a noncompetitive antagonist of the N-methyl-D-Aspartate (NMDA) receptor. It demonstrates several beneficial pharmacodynamic effects in the setting of hypotension due to the fact that it increases sympathetic tone, which leads to an increase in heart rate, blood pressure, and cardiac output.⁷ This is a significant advantage in a cohort of trauma patients including adults, children, and polytrauma patients who are hypotensive secondary to hypovolemia.⁷ A popular medication used

in the induction of anesthesia and maintenance of general anesthesia is propofol. Propofol is a short acting, hypnotic/amnestic agent. Although propofol has an appealing pharmacokinetic profile, it has been associated with hypotension. Shearin et al⁸ determined that 16.5% of trauma patients who were administered propofol only infusions developed hypotension. Therefore, an alternative to propofol alone is the mixture of ketamine with propofol known as "ketofol". According to Smischney et al,⁹ propofol was more likely to generate a 20% reduction in systolic blood pressure compared to "ketofol" which was associated with significantly improved hemodynamic stability.

Total intravenous anesthesia in the deployed setting has additional practical advantages over volatile anesthetics. In wartime trauma resuscitation, the ability to continue to provide anesthesia despite loss of power or equipment failure is crucial. A total intravenous technique can be accomplished without additional equipment or power supply. Occasionally, the deployed setting introduces additional tactical considerations such as environments that require light and noise discipline. An intravenous anesthetic may prove to be a better option than a cumbersome anesthesia machine. The total intravenous technique also allows the anesthesia provider the ability to continuously provide en route patient transport by litter, ground, or air without interruption of amnesia and analgesia.

Recent changes in tactical combat casualty care doctrine have increased the recognition and availability of ketamine in the deployed setting. First line medics are now more familiar with ketamine and frequently include it as a first line adjunct in their medic aid kits. The consorted use of ketamine across the continuum of combat care enables the consolidation of resources in extreme conditions where resupply may be constrained.

CONCLUSIONS

The discussion about anesthesia in the deployed austere environment is not a new concept. In 2009, Barras et al¹⁰ summarized many of the same discussion points made in this paper. New paradigms in Army medicine and emergent tactical requirements necessitate smaller, more agile surgical teams to conduct missions with a reduced logistical footprint. Complacency with current practice and equipment should not be status quo for the next conflict. An increased investment in time and resources should be expended on predeployment training and the continued pursuit of alternative anesthetic techniques. Demonstrated success with total intravenous anesthesia remains one of the most promising developments from years of combat lessons learned. Continued educational and training efforts should focus

on ensuring that every military anesthesia provider is comfortable delivering TIVA in an unstable trauma patient. Doctrine should support formal TIVA education in military anesthesia curricula for both nurse anesthetist and physician anesthesiologists. Prior to deployment, anesthesia providers should demonstrate proficiency in the administration of TIVA to trauma patients as part of predeployment training.

The effectiveness of any anesthesia provider, however, is also dependent on the effectiveness of the tools they have. Research and development should focus on new and innovative ways of delivering combat anesthesia. Promising investigative projects such as closed loop inhalation anesthesia and racemic versus +S isomer ketamine have been documented in anesthesia journals, however, continued research is necessary. The increased interest in TIVA across the field of anesthesia has prompted several biomedical manufacturers to develop target controlled infusers. Target controlled infusers use specifically programmed syringe drivers to enable a more precise titration of anesthetic medication. The infuser operates on algorithms based upon pharmacokinetic and pharmacodynamic data to an estimated target concentration in blood.¹¹ With continued development and clinical trials, this type of infuser shows tremendous promise for future military use in the deployed setting.

Collaborative triservice efforts should guide future studies and focus on the effectiveness of different anesthetics throughout the continuum of care on the battlefield. Future education and deployment training should focus on physiological endpoints and be informed by clinical outcomes. Numerous technological advances have occurred in anesthetic delivery throughout the past decade of war. It is now imperative that we retain these lessons, learn from our missteps, and continue to develop techniques that allow for quicker adaptation to meet future battlefield requirements.

REFERENCES

1. More Durable Aerospace, Marine, and Rail Equipment [internet]. Du Pont Corporation Website; 2014. Available at: <http://www.dupont.com/products-and-services/fabrics-fibers-nonwovens/fibers/uses-and-applications/aero-space-marine-rail.html>. Accessed September 24, 2015.

2. Arnold M. *US Army Oxygen Generation System Development*. Defense Technical Information Center Website; 2010. Report RTO-MP-HFM-182. Available at: <http://dtic.mil/dtic/tr/fulltext/u2/a581789.pdf>. Accessed September 24, 2015.
3. Schifilliti D, Grasso G, Conti A, Fodale V. Anaesthetic-related neuroprotection: intravenous or inhalational agents?. *CNS Drugs*. 2010;24:893-907.
4. Joint Theater Trauma System Clinical Practice Guideline [internet]. Fort Sam Houston, TX: US Army Institute of Surgical Research; 2014. Available at: http://www.usaisr.amedd.army.mil/cpgs/Trauma_Anesthesia_16Jun2014.pdf. Accessed September 24, 2015.
5. Himmelseher S, Durieux ME. Revising a dogma: ketamine for patients with neurological injury? *Anesth Analg*. 2005;101:524-534.
6. Englehart MS, Allison CE, Tieu BH, et al. Ketamine-based total intravenous anesthesia versus isoflurane anesthesia in a swine model of hemorrhagic shock. *J Trauma*. 2008;65:901-909.
7. McDermott P, Sebastian J. Should Ketamine be used as an induction agent in traumatic brain injury? *Br J Hosp Med*. 2013;74(9):538.
8. Shearin AE, Patanwala AE, Tang A, Erstad BL. Predictors of hypotension associated with propofol in trauma patients. *J Trauma Nurs*. 2014;21(1):4-8.
9. Smischney NJ, Beach ML, Loftus RW, Dodds TM, Koff MD. Ketamine/propofol admixture (ketofol) is associated with improved hemodynamics as an induction agent: a randomized, controlled trial. *J Trauma Acute Surg*. 2012;73:94-101.
10. Barras P, McMasters J, Grathwohl K, Blackbourne L. Total intravenous anesthesia on the battlefield. *US Army Med Dep J*. January-March 2009:68-72.
11. Morton NS. Total intravenous anesthesia (TIVA) and target controlled infusion (TCI) in children. *Paediatr Anaesth*. 2013;3:37-41.

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Roles of Occupational Therapists in Theater, Past and Present

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ABSTRACT

The impetus to deploy occupational therapy (OT) assets into theaters of operation lies in the occupational therapist's ability to evaluate the effect of physical and/or behavioral symptoms on functional performance and effectively develop individualized interventions. Occupational therapy utilization has been robust during 14 years of continuous deployments in Iraq and Afghanistan. Occupational therapy's indoctrinated role in combat is solely with the combat and operational stress control missions, however, the skills and capabilities of this profession have demonstrated efficacy in other specializations, including concussion care. The effectiveness of OT interventions is demonstrated with improved return to duty (RTD) rates for casualties suffering with combat and operational stress reactions where OT was a major component of a restoration and reconditioning program. As well, postconcussion RTD rates have been linked to the broad skill sets inherent in OT that allow casualties to remain in theater from the point of injury to complete recovery and RTD.

Occupational therapy (OT) is defined as "the art and science of helping people do day-to-day activities important and meaningful to their health and well-being through occupational engagement."¹ Since its inception, OT was grounded on the concept of engagement in therapeutic activities to promote health. Today, there is a growing multidisciplinary appreciation for occupational engagement and its associated well-being, which highlights the health effects of participating in multiple activities and occupations.²

MILITARY OCCUPATIONAL THERAPY WARTIME ROLES

The involvement of occupational therapists as reconstruction aides during World War I created national professional recognition. The executive order of 1917 authorized the Civil Service Commission to employ occupational therapists as civilians in the Army Medical Department for the duration of the war emergency and to accompany hospitals for overseas duty.³ The aim was to employ medical aides and teachers in the reconstruction of the injured Soldier. The intent was for this curative phase to allow Soldiers to return to active duty rather than "be discharged to live reliant upon a pension, as an economic drain on the country."⁴ Since the early 1800s, training individuals in activities of daily living and remedial work were used in the rehabilitation therapy of mentally ill patients.³

By the advent of World War II (WWII), OT's presence in the military had diminished. There were only 5 Army hospitals providing OT services and only 8 occupational therapists serving as civilians in the Army.³ However,

due to the war escalation, by 1945 there were 899 civil service occupational therapists, including 452 apprentices, serving in the United States.³ Following the WWII carnage resulting in over 40 million casualties worldwide, departments of physical medicine were developed which laid the foundation for OT practice in physical disabilities and orthopedics. By 1947, occupational therapists were granted military designation with the creation of the Women's Medical Specialist Corps. In 1955, Public Law No. 84-294 allowed the Army Medical Specialist Corps (AMSC) to commission men into the Corps.³

The Army OT support for the Vietnam War was provided primarily in Japan, Hawaii, and the continental United States. In 1971, MAJ Hetty Ricker became the first AMSC OT officer assigned to the combat zone in South Vietnam where she served as the OT consultant to the US Army, Vietnam Surgeon.³ Her 3 missions were to assist in establishing a drug abuse treatment program at the 3,000-bed convalescent center at Cam Ranh Bay, to strengthen rehabilitation programs in 13 other Army drug control treatment facilities, and to evaluate OT support and education in the medical civil assistance programs aiding the Vietnamese population.

During Operations Desert Storm and Desert Shield, occupational therapists were represented in the first hospitals to deploy to Southwest Asia. This was in marked contrast to medical support mobilizations during the Korean and Vietnam Wars. In October 1990, MAJ Mary Laedtke, and an enlisted OT assistant became the first occupational therapists to be assigned to a Combat Stress

Control Team deployed to Operation Desert Storm. The team's task was to evaluate, in the combat environment, the success of methods and techniques developed to manage combat stress.³

OCCUPATIONAL THERAPY UNIQUE ROLES

Occupational therapists perform multiple functions in the combat or garrison environments. Apart from a background in orthopedics and physical dysfunction rehabilitation, occupational therapists train in neurology and behavioral health rehabilitation. Occupational therapists evaluate the effects of physical, cognitive, neurologic, or psychosocial symptoms on functional performance in the deployed environment. Because of the unique ability to conduct analysis, occupational therapists are skilled to develop activities of increasing challenge (grading) to facilitate healing and effective return to duty (RTD). The ability to make environmental modifications enables occupational therapists to facilitate cognitive, emotional, and physical rehabilitation. Finally, occupational therapists address physical, cognitive, and psychosocial symptoms in conjunction with job analysis to ensure successful RTD.

OCCUPATIONAL THERAPY AND CONCUSSION CARE IN THEATER

Mild Traumatic Brain Injury (mTBI) is also known as a concussion. It is important to note that "mild" does not refer to symptoms, but rather injury severity. Concussion is the preferred term when communicating with service members. Concussion became the signature injury for the Operations Iraqi Freedom and Enduring Freedom due to the prevalence of improvised explosive devices. This is in contrast to posttraumatic stress disorder that was the signature injury for the Vietnam War. Prior to 2010, up to 90% of concussed service members remained undiagnosed, redeployed, and/or were evacuated from theater. The condition was not well understood and there was a lack of standardized training, facilities, staffing, and medical documentation. Since 2010, an increased awareness of injury events, evaluation, and treatment has occurred. *Department of Defense Instruction 6490.11*⁵ was published to provide policy guidance for the management of mTBI/concussion care in the deployed setting. In theater, concussion treatment resulted in an improved RTD rate (92% - 95%).

The OT role in concussion care is threefold: evaluate, treat, and educate. First, evaluation of cognitive, psychosocial, physical, and vestibular injuries is required to assess effect on functional performance. Second, treatment is provided by graded activities and environmental modification. Service members begin with rest and gradually progress through various phases of recovery in which

treatments are designed to provide increasing physical, cognitive, and vestibular challenges that simulate individual occupational demands until performance does not trigger symptoms. The appearance of no new symptoms at rest and with exertion is the cue to evaluate the service member for readiness to RTD. Recommendations are given to the service member's provider who ultimately determines fitness for duty. Third, occupational therapists provide detailed education in 3 primary venues: (1) to concussed service members on how to facilitate healing and the expectation for recovery; (2) to commanders and line leaders on the expected recovery from mTBI as well as the line leader's roles and responsibilities; and (3) to medics and medical providers on concussion care, current policies, and treatment algorithms.

Concussion recovery is a physiological recovery. When deployed in the combat theater, occupational therapists act as force multipliers by enabling service members to recover from concussion and remain with their unit following injury. Due to closely monitoring symptoms, providing cognitive and physical rest, and ensuring Soldiers are fit to perform occupational tasks before returning to work, occupational therapists preserve the force for combat readiness and maintain unit integrity. Occupational therapists are an asset for both service members and line leaders.

COMBAT STRESS CONTROL

Serving in a combat environment exposes service members to demands and inherent dangers that result in experiencing physiological and emotional stress which is defined as combat stress.⁶ Combat occupational stress reactions (COSR) are the predictable, expected, emotional, intellectual, physical, and/or behavioral reactions of service members who have been exposed to stressful events in combat or military operations other than war.⁶ Combat operational stress control (COSC) aims to identify, prevent, and manage adverse combat and operational stress reactions.^{6,7} There are 4 Army tactical tasks taken from *Army Doctrine Reference Publication 1-03*⁸ that guide COSC doctrine: ART 4.3.1 Provide Combat Casualty Care^{8(p4-90)}; ART 4.3.1.5 Provide Behavioral Health Neuropsychiatric Treatment^{8(p4-94)}; ART 6.7 Provide Force Health Protection^{8(p6-51)}; and ART 6.7.3 Provide Combat and Operational Stress Control Prevention.^{8(p6-54)} Occupational therapists within the COSC detachment return service members to duty by accomplishing 3 objectives:

1. Assist the service member to develop a sense of belonging. Occupational therapists facilitate the reestablishment of the service members' relationships with their leaders and their peers.

PERSONNEL CHANGES THAT IMPACTED CARE AND OUTCOMES

2. Help the service member develop an internal locus of control, mediated through the stress of graded activities. Occupational therapists provide purposeful activities to enhance functional performance.
3. Facilitate the improvement of communication skills using cognitive behavior therapy facilitated by each occupational therapist's therapeutic use of self.⁹

OCCUPATIONAL THERAPIST ROLES IN THE FITNESS/ RESTORATION TEAM

Although occupational therapists contribute in the 9 functional roles of COSC,⁶ they are a stronger force multiplier when employed in the functional areas of restoration¹⁰ and reconditioning, and during the conduct of unit needs assessments. Occupational therapists work to identify stressors (physical) and assess performance (reactions), teach prevention to facilitate adapting coping and social skills, and engage service members in meaningful, purposeful activities.

COSC POPULATIONS AND OCCUPATIONAL THERAPY'S FOCUS

During Operations Iraqi Freedom and Enduring Freedom, occupational therapists learned that COSC operations were dictated by the populations needs. This was accomplished by coupling Maslow's hierarchy of needs theory¹¹ to the maturation of the battlefield to determine the focus of intervention as illustrated in the Figure. Cohesive teams are developed through extensive training opportunities and that is what was delivered early in the conflict to occupy immature battlefields. Immature battlefields necessitate predominately combat operations that are time and energy intensive. In this stage, service members require restoration to meet Maslow's fundamental physiological needs and a safe environment to ensure recovery (rest, sleep, etc). As the conflict protracts, extensive training is replaced by personnel turnover and hasty operational deployment, generating a population with fragmented criterion to occupy a mature battlefield, who now require the development of team cohesion. The mature battlefield requires predominately stabilization and reconstruction operations in a relatively safe environment where their basic physiological needs (food, shelter, sleep) are met. These service members require reconditioning, as the primary needs in this population are a sense of belonging and esteem, which coincides with Maslow's higher levels of self-esteem (M. Callison et al, unpublished data, 2012).

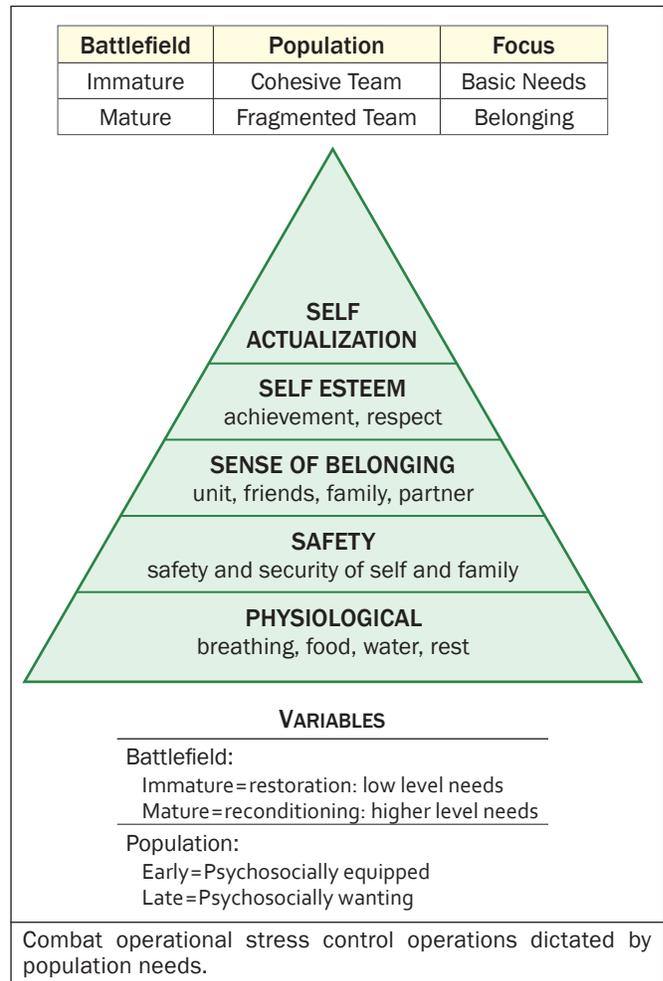
COSC RECOVERY OF ACUTE COSR

The Restoration program is typically a 24-72 hour program.^{6(p10-1)} The focus is on nutrition, sleep hygiene, personal hygiene, graded activities, and a structured military environment. Evaluation is conducted to

determine adaptive versus maladaptive behaviors. Reconditioning involves Restoration and additional training up to 7 days.^{6(p12-1)} Life skills classes are conducted daily and service members receive behavioral health officer follow-up. Service members are provided a structured, scheduled environment to prevent them from adopting a patient role.¹⁰ The aim is to restore resiliency through physical, emotional, spiritual, and cognitive skills. The Table presents data concerning the patients seen in one year at a Restoration center.

OCCUPATIONAL THERAPY UNIQUE SKILLS APPLIED IN THE COSC

Occupational therapy's intake focus is on service members' functional performance.¹² It is the only discipline on the interdisciplinary team assessing work skills/abilities. Other providers have commented on the value of this particular skill. Occupational therapists use the same unique skills used in concussion care. However, in COSC, the graded tasks and environmental modifications vary based on the specific needs of each service member. Treatments are designed to provide increasing



physical, cognitive, and psychosocial challenges that simulate individual occupational demands until they are able to perform occupational demands, illustrated in the Figure. For example, while in concussion care, treatment begins with modifications to create a quiet environment; in restoration, the environment is modified to maintain a structured military environment to prevent service members from adopting a “patient role.” In a comparison of restoration/reconditioning, units using both behavioral health-directed and OT-directed intervention, there was a 17% greater likelihood of RTD when compared to those restoration/reconditioning teams that did not include occupational therapists (T. L. Brininger et al, unpublished data, 2013).

OCCUPATIONAL THERAPY RECOMMENDATIONS FOR CONCUSSION CARE

Doctrine: Occupational therapy services and other behavioral health disciplines are not written in the TBI doctrine. It is important that the distinctive roles for each provider be written in the TBI doctrine similar to that of the COSC doctrine in order to provide a thorough understanding of roles and responsibilities for future conflicts.

Manning: The Occupational Therapist (Area of Concentration (AOC) 65A) listed on the TDA^a be added to TBI doctrine.

Training: Training is available and requirement is necessary. This includes the Interdisciplinary TBI Training for Deploying Providers NCAT(ANAM).^b Each deploying provider is to be a graduate of the Captain’s Career Course (at a minimum).

OCCUPATIONAL THERAPY LESSONS LEARNED IN COSC

Doctrine: The current COSC doctrine contained in *Field Manual 4-02.51*⁶ works well when it is employed. An update is needed to reflect current occupational therapy nomenclature. Currently, service members referred to Restoration require an evaluation by a behavioral health provider in order to avoid Restoration misuse.

Manning: There is no occupational therapy asset at the main support medical company level. Recommend filling the established COSC OT position with a Major (O-4) as listed in the TOE.^c

Training: Train as a team with other COSC providers to have cohesiveness and gain insight on provider roles.

US Military Service			Number of Individual Patient Combat Deployments		
Service	No.	%N	Deployment	No.	%N
Army	277	84%	1st	176	55%
Air Force	34	10%	2nd	84	26%
Navy	15	5%	3rd	31	10%
Marine Corps	2	1%	4th	17	5%
			5 or more	12	4%
Gender No. (%N)			Posttraumatic Stress Disorder		
Male	Female		Diagnosed	No.	%N
275 (84%)	53 (16%)		Yes	19	6%
			No	302	92%
			Unknown	7	2%
5 Highest Percentages of Patient Military Occupational Specialties			Experienced Combat?		
MOS	No.	%N	Response	No.	%N
Infantry	54	17%	Yes	71	22%
Military Police	27	8%	No	248	76%
Truck Driver	27	8%	Unknown	7	2%
Mechanic	16	5%			
Cook	15	5%			
5 Most Listed Patient Deployment Locations			5 Most Cited Reasons for Seeking Treatment		
Location	No.	%N	MOS	No.	%N
Bagram Airfield	155	48%	Occupational	133	17%
Shank	19	6%	Adjustment Disorder	50	8%
Stone	14	4%	Relationship	41	8%
Salerno	12	4%	PTSD	19	5%
Gardez	9	3%	Leadership	11	5%

US military service members seen from February 6, 2010 to February 9, 2011 at the Freedom Restoration Center in Afghanistan. N=328; Return to duty rate of this period, 97%. Data provided by CPT Jason Judkins, SP, USA.

There are current occupational therapy efforts to support garrison behavioral health programs. The Management of Combat and Operational Stress Control Casualties postprofessional behavioral health course currently trains AOC 65A (Occupational Therapist), and military occupational specialties 68L (Occupational Therapy Specialist) and 68X (Behavioral Health Specialist). Ensuring all receive the training required to vet for suicidal or homicidal tendencies is very important.

REFERENCES

1. Cohn ES, consulting ed; Schell BAB, Gillen G, eds. *Willard and Spackman's Occupational Therapy*. 12th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2003:50.

^a Table of Distribution and Allowances: Prescribes the organizational structure, personnel, and equipment authorizations, and requirements of a military unit to perform a specific mission for which there is no appropriate table of organization and equipment (defined in note c below).

^b NCAT indicates neurocognitive assessment tool; ANAM, Automated Neuropsychological Assessment Metrics.

^c Table of Organization and Equipment: Defines the structure and equipment for a military organization or unit.

PERSONNEL CHANGES THAT IMPACTED CARE AND OUTCOMES

2. Stav WB, Hallenen T, Lane J, Arbesman M. Systematic review of occupational engagement and health outcomes among community-dwelling older adults. *Am J Occup Ther.* 2012;66(3):301-310.
3. Hartwick AMR. *The Army Medical Specialist Corps: The 45th Anniversary.* Washington, DC: US Army Center of Military History; 1993. Available at: <http://www.history.army.mil/html/books/085/85-2/index.html>. Accessed February 18, 2016.
4. Gutman SA. Influence of the U.S. military and occupational therapy reconstruction aides in World War I on the development of occupational therapy. *Am J Occup Ther.* 1995;49(3):256-262.
5. *Department of Defense Instruction 6490.11: Policy Guidance for Management of Mild Traumatic Brain Injury/Concussion in the Deployed Setting.* Washington, DC: US Dept of Defense; 2012. Available at: <http://www.dtic.mil/whs/directives/corres/pdf/649011p.pdf>. Accessed February 18, 2016.
6. *Field Manual 4-02.51: Combat and Operational Stress Control.* Washington DC: US Dept of the Army; July 2006.
7. *Field Manual 4-02: Army Health System.* Washington DC: US Dept of the Army; August 2013:12-2.
8. *Army Doctrine Reference Publication 1-03: The Army Universal Task List.* Washington DC: US Dept of the Army; October 2015.
9. Holmqvist K, Holmefur M, Ivarsson AB. Therapeutic use of self as defined by Swedish occupational therapists working with clients with cognitive impairments following acquired brain injury: A Delphi study. *Aust Occup Ther J.* 2013;60(1):48-55.
10. Smith-Forbes E, Najera C, Hawkins D. Combat operational stress control in Iraq and Afghanistan: Army occupational therapy. *Mil Med.* 2014;179:279-284.
11. Maslow AH. A dynamic theory of human motivation. In: Stacey CL, DeMartino M, eds. *Understanding Human Motivation.* Vol XV. Cleveland, OH: Howard Allen Publishers; 1958:26-47.
12. Gerardi S, Newton S. The role of the occupational therapist in CSC operations. *US Army Med Dep J.* July-September 2004:20-27.

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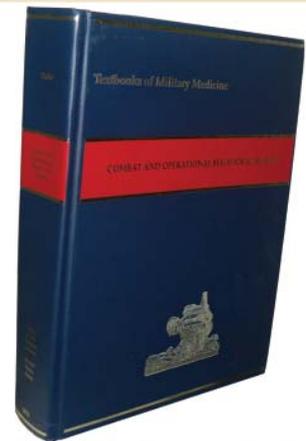
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COMBAT AND OPERATIONAL BEHAVIORAL HEALTH

SECTION V - SURVEILLANCE AND INTERVENTION

CHAPTERS 24-26 DISCUSS ARMY SUICIDE PREVENTION EFFORTS

This comprehensive publication covers all aspects of behavioral health in the military population, including traumatic brain injury, posttraumatic stress syndrome, combat and operational stress control, training for resiliency and other preventive measures, pain management, grief, family dynamics, rehabilitation and occupational therapy, medications, suicide prevention, forensic psychiatry, detainee care, substance abuse, eating disorders, ethics, and the roles of military behavioral health providers and chaplains, as well as the military's evolving behavioral health policy and practices.



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Wounded, Ill, and Injured Challenges

MG Stephen L. Jones, MC, USA

ABSTRACT

The *Washington Post* articles of February 2007 led to a close examination of the care provided Wounded Warriors at Walter Reed Army Medical Center. Subsequent reports by the President's Commission, Independent Review Group, and Defense Health Board all recommended ways to improve care. Joint Task Force National Capital Region Medical was established to implement the recommended improvements in Warrior care, and the recommendations of the Base Realignment and Closure Commission to close Walter Reed and realign the staff into a new Walter Reed National Military Medical Center and Fort Belvoir Community Hospital. It accomplished these tasks, maintained existing wounded, ill, and injured care, and safely transferred patients during the height of the fighting season in Afghanistan. It successfully accomplished its mission through engaged leadership, establishing an appropriate environment for Warrior care, careful management of casualty flow, and robust communication with all parties affected by the changes. The lessons learned in Warrior care should be considered when planning future military medical operations.

BACKGROUND

From the onset of the wars in Afghanistan and Iraq, the National Capital Region (NCR) served as America's primary reception site for returning casualties and trauma care. Flights from Landstuhl Regional Medical Center landed at Joint Base Andrews where the 779th Medical Group operated an aeromedical staging facility. Almost all critical casualties were evacuated to Ladhstuhl Army Medical Center with 50% of all inpatients being taken to Walter Reed Army Medical Center (WRAMC) or National Naval Medical Center (NNMC) or Brooke Army Medical Center/San Antonio Military Medical Center with most stayed for outpatient rehabilitation at WRAMC.

The *Washington Post* articles published in February 2007 led to a close examination of the care provided the wounded Warriors at WRAMC.^{1,2} In these articles, Dana Priest described the lodging conditions in Building 18 and difficulties faced by outpatients. The President's Commission led by Bob Dole and Donna Shalala found high quality clinical care, but noted problems with handoffs between inpatient and outpatient care, between the separate Department of Defense and Veterans Administration health care systems, and the separate disability systems.³ The Independent Review Group established by the Secretary of Defense found first class care from the battlefield to the tertiary medical facility which set a recognized standard of excellence in trauma care.⁴ However, they noted that a breakdown in health

services and care management occurred once the service member transitioned from inpatient to outpatient status. Other key findings were that comprehensive care, treatment, and administrative services were not provided in an interdisciplinary, collaborative manner. A clear standard was lacking for the qualifications and training of outpatient case managers, there were insufficient behavioral health staff, and more work was needed in the diagnosis and treatment of traumatic brain injury and posttraumatic stress disorder. Significant improvements arose from the lessons learned. The Army increased funding for WRAMC, constructed new facilities including a state of the art amputee center, and implemented efforts to retain staff leaving because of the impending closing of Walter Reed. It established the Warrior Transition Command and implemented new policies to provide better support to wounded (ie, combat related injured), ill, and injured (ie, noncombat related injuries) along with their families.

The Base Realignment and Closure Commission (BRAC) recommendation to close WRAMC and establish the Walter Reed National Military Medical Center (WRNMMC) and Fort Belvoir Community Hospital (FBCH) also led to an evaluation of Warrior care. Senior military and elected leaders closely examined plans to transfer patients during the height of the fighting season in Afghanistan when casualty flows were expected to peak. The recommendations from this second evaluation, like the first, brought further resources and

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additional improvements. Joint Task Force National Capital Region Medical was established to implement the BRAC recommendations, apply these lessons, and those learned during execution of their mission. The challenges they faced, and their approach to overcoming those challenges are presented below.

THE MILITARY PROBLEM

Joint Task Force National Capital Region Medical (JTF CapMed) was tasked to continue existing wounded, ill, and injured operations in the NCR while constructing new facilities, building new teams, and establishing new patient care processes. Staff would have to prepare for a projected increase in casualty flow, ensure patient safety throughout the transfer, overcome Army, Navy, Marine Corps, and Air Force culture and policy differences, and maintain standards of multiple accrediting organizations. Components of the solution included engaged leadership, an appropriate environment for Warrior care, careful management of casualty flow, and robust communication with all parties affected by the changes.

ENGAGED LEADERSHIP

Engaged leadership requires far more than regular casualty visits. Leaders must take the time to gather facts and truly understand the situation. Effective leaders provide more than purpose, direction, and motivation; they also ensure careful planning is conducted and adequate resources are provided. They change overly bureaucratic policies that hinder care, develop solutions to the challenges that arise, and monitor implementation of the solutions. Senior civilian and military leadership accomplished this through the reviews noted above, and a follow-up evaluation by the Defense Health Board (DHB) entitled “Achieving World Class.”⁵ The latter review examined the planned integration of military medical facilities in the NCR, and plans for WRNMMC and FBCH to determine if they were being designed and constructed to be world-class medical facilities. The first recommendation of the DHB provided a definition of world-class medical facility which was codified in the 2010 National Defense Authorization Act. The second was to empower one official with singular organizational and budgetary authority and be staffed appropriately to manage and lead the healthcare integration efforts and operations in the NCR. The third was to develop a Comprehensive Master Plan for an NCR integrated delivery system and for WRNMMC. Additional recommendations focused on facility and infrastructure improvements.

The JTF CapMed staff followed the standard military planning process to implement the recommendations discussed above. They developed a concept of operations

Table 1. Joint Task Force National Capital Region Medical Concept of Operations.

Integrated system of care for Wounded, Ill, and Injured comprised of Service and Military Treatment Facility programs, with Installation/Base, Veterans Affairs, and Volunteer Organization support.
One standard of clinical care, rehabilitation and recovery that is patient-centered, holistic and builds independence and resiliency.
Walter Reed National Military Medical Center Unique Capabilities Amputee and complex battle trauma Severe traumatic brain injury and neurosurgery Eye trauma Cardiothoracic surgery
Fort Belvoir Community Hospital Unique Capabilities Residential substance abuse treatment Dual diagnosis with substance abuse

Table 2. Responsibilities of Joint Task Force National Capital Region Medical.

Military Treatment Facility Responsibilities Provide patient/family-centered clinical care and rehabilitation. Operate a Warrior Family Coordination Cell. Conduct timely and responsive Medical Evaluation Board (MEB) system. Administer military Service-specific MEB. Contribute to an optimal healing environment. Provide other support services as required.
Service Responsibilities Maintain command and control over Warriors to include but not limited to the Uniform Code of Military Justice, transfer authority, movement, and family support. Maintain personnel accountability. Administer Service-specific personnel services. Maintain Service Wounded, Ill and Injured Warrior Programs. Assure personnel availability for continuity of healthcare and rehabilitation.
Installation/Base Responsibilities Provide base operation services (eg, childcare, dining, lodging, and on-campus transportation). Ensure campus is compliant with Americans with Disabilities Act Accessibility Guidance. Operate fitness center, morale, welfare & recreation activities, the Exchange/PX, and related entities. Contribute to an optimal healing environment.

(Table 1) and clearly assigned responsibilities to the hospital, military service, and installation (Table 2). They integrated the efforts of the many agencies that played a role in Warrior care and applied a single standard of care to all military services. They analyzed every aspect of care from the patient and family’s perspective, and provided additional services like child care, transportation, and internet access which supported the Warrior’s rehabilitation and reintegration. During execution of the BRAC recommendations, JTF CapMed adapted to many challenges: increasingly severe casualties, significant construction delays, a telecommunications strike, and even an earthquake. At the last minute they transferred patients a day early because of an approaching hurricane.

ENVIRONMENT FOR WARRIOR CARE

The DHB definition of a World Class Medical Facility addressed 6 domains shown in Table 3. The recovery, rehabilitation and reintegration of Warriors also required a campus specifically designed for that purpose; the elements of the campus are outlined in Table 3. The environment for Warrior care considered far more than facilities. It included the exchange of clinical information while casualties were still in theater, an appropriate reception at Joint Base Andrews, and transfer to the medical facility in a mobile ICU if required. The interaction with families during and after casualty notification was equally important in establishing a supporting environment. Families experienced less stress when provided information about their service members' conditions, their progress en route home, and what to expect upon arrival at Walter Reed.

Facility lessons learned at WRAMC were applied during construction of WRNMMC and FBCH.⁸ The JTF CapMed modified the standard Army Warrior Complex plans to better suit more severely wounded casualties. Warrior lodging was constructed with 2-bedroom suites that included a kitchen, laundry facilities, and living area. Each bedroom had a separate bathroom and large closet. They provided amputees additional storage space for prosthetics, electrical outlets to recharge batteries, and allowed more privacy for nonmedical attendants. Wounded Warriors assisted in the selection of furniture and suggested modifications. Postconstruction modifications included installation of tubs to bathe children and to allow amputees to soak themselves. Staff personally navigated the campus in wheel chairs and spent much time with casualties and families to discover remaining

accessibility obstacles. This guided improvements to flow within the hospital, modification of sidewalks, addition of more automatic door openers and handicapped parking. The installation developed plans to improve access to athletic fields and build biking and running trails.

The Independent Review Group, Defense Health Board, Army Dismounted Complex Blast Injury Task Force, and Pain Management Task Force all recognized multidisciplinary care was a critical element of the clinical environment.^{4,7} It was particularly important for pain management, treatment of multiple amputees, casualties with complex abdominal and genitourinary injuries, and managing transitions in care. The transition from inpatient to outpatient status was a high risk event. A multidisciplinary approach involving inpatient and outpatient clinical staff, Warrior Transition Unit cadre, case managers, and administrative personnel was essential to a smooth transition. Clinical details were shared where needed and occupational therapy staff evaluated lodging for suitability. Discharges at night and on weekends were avoided, especially for high risk behavioral health patients. Finally, inpatient staff were required to make personal contact with Warrior Transition Unit cadre at discharge and not rely on email to transmit information. Once Warriors transitioned to outpatient status, non-medical attendants assisted those who were unable to perform activities of daily living. Since many were not otherwise eligible, policy changes allowed nonmedical attendants to receive health care at the medical facility. When Warriors did not have a suitable family member to serve as a nonmedical attendant, the Army designated another Soldier to assist.

The Warrior Transition Unit cadre contributed significantly to the environment for Warrior care. They provided support to casualties and families that was normally the responsibility of the home station chain of command. Families required even greater assistance after abruptly moving to assist in the rehabilitation of their Warrior. Squad leaders were the first line of support for Warriors and families. The ratio of squad leaders to Warriors was standard across the Army and adequate for most medical facilities. It was not adequate, however, for the medical centers caring for those with the devastating injuries seen in Afghanistan after 2009. A typical squad at WRNMMC in September 2011 included 10 Warriors; of these 7 were amputees, and over half of them were multiple amputees. Six of the 7 amputees were accompanied by families who also required support. Severely wounded Warriors averaged 3-5 clinic appointments a day, requiring squad leaders to track 150 to 250 appointments per week. The more complex casualties required more medications, behavioral health care, intense case

Table 3. Environment for Warrior Care
World-Class Medical Facility
Basic Infrastructure
Leadership and Culture
Processes of Care
Performance
Knowledge Management
Community and Social Responsibility
Holistic Wounded Warrior Campus
Outpatient Rehabilitation that encourages reintegration into the community
Lodging specifically designed for Warrior and Family needs
Dining
Childcare and playgrounds
Transportation
Outpatient medical care for nonmedical attendants and families
Service Wounded, Ill and Injured Programs
Family and other support services
Veterans Affairs and Charitable Organizations
Social programs
Internet access in Military Treatment Facility, Lodging and Gym
Designed for accessibility

management, and more administrative support. Since many had served in Afghanistan and Iraq 3 or 4 times, they and their families were recovering from the cumulative stress of multiple deployments.

The social environment is a key element of both rehabilitation and reintegration. Warriors and families developed a sense of camaraderie at WRAMC's outdoor barbeque and playground which was the center of social life. This environment was difficult to duplicate at WRNMMC. The increasing severity of wounds, cumulative stress from multiple deployments, and more comfortable lodging at WRNMMC led many Warriors to remain isolated in their rooms. The activities sponsored by private organizations on and off campus assisted with their reintegration into society. As they progressed with rehabilitation, Warriors were moved to leased apartments in the community to learn to live independently before returning home.

MANAGEMENT OF CASUALTY FLOW

As casualties declined in 2007 following the surge in Iraq, Army surgical leadership concentrated acute amputee care at WRAMC to maintain expertise. Burn casualties decreased as well, so there were fewer direct casualty flights to San Antonio. As a result, by 2010 92% of all critically injured Warriors were taken to the NCR. In the summer of 2010, a significant increase in casualties from Afghanistan was noted. Many were severely wounded by improvised explosive devices during dismounted operations and sustained high lower extremity amputations, pelvic, genital, and spine injuries. In 2009, there were 49 single and 13 multiple major limb amputations in Afghanistan and Iraq. This rose to 77 single and 25 multiple major limb amputations in 2010.⁹ The peak in casualty flow during those years occurred from July through October. The closure of WRAMC was scheduled for August 2011 when casualty flow was projected to be high, and planned operating room renovations at WRNMMC in accordance with DHB recommendations would severely limit capacity at the same time.

The JTF CapMed leadership recognized this challenge in the summer of 2010 and coordinated with the US Transportation Command (TRANSCOM) to redistribute critically injured patients to Brooke Army Medical Center, which was also undergoing a BRAC evolution at Lackland Air Force Base which involved reduction in services at Wilford Hall Medical Center. The change required reopening of the Aeromedical Staging Facility at Joint Base San Antonio–Lackland, and was implemented in January 2011. It allowed better use of the Military Health System capacity to treat amputees, and moved many Warriors closer to home, families and friends.

During the first 3 months of 2011, 145 casualties were regulated to the NCR rather than the projected 424.

To determine the facility and staff required to support the increasing casualty flow, JTF CapMed staff developed a model as described by Kepner and Spencer elsewhere in this issue.* The model estimated the number of ICU beds, medical surgical beds, and operating room hours needed for different levels of casualty flow. The capacity for amputee care at Brooke Army Medical Center and Naval Medical Center, San Diego, were included to better inform decisions on medical regulation. The model was adjusted after the 2011 casualty season to account for the increased numbers of and requirements for multiple amputees. The JTF CapMed also projected requirements for outpatient rehabilitation staff and lodging which were increasing as the average length of stay for casualties with multiple extremity amputations rose to 2 years. On August 2, 2011, as the NNMC approached capacity limits, JTF CapMed requested temporary staffing augmentation from the military services for its operating rooms, intensive care unit, medical surgical wards, radiology, and occupational therapy sections. It made contingency plans for additional lodging, including Americans with Disabilities Act (Pub L No. 101-336, 104 Stat 328 (1990)) compliant rooms, and transportation. Requirements were projected well in advance to allow time for the movement of personnel and execution of contracts.

COMMUNICATION

Communication of clinical information assisted staff to prepare for a casualty's arrival. The web based Joint Patient Tracking Application (JPTA) provided patient information once a casualty reached the combat support hospital. The application which was developed by the Landstuhl Regional Medical Center and implemented across the Military Health System in 2004 provided information earlier and in more detail than the TRANSCOM Regulating and Command & Control Evacuation System, commonly known as TRAC2ES. The Landstuhl Medical Center staff also participated in Joint Theater Trauma System conferences to discuss the clinical status of casualties en route.

Communication of information to families after casualty notification is equally as important, but was limited in the first years of the conflict. Families were provided limited details of a casualty's condition during initial notification, then often heard nothing for days. Implementation of JPTA allowed providers at the home station to keep families better informed. The Warrior and Family Quick Reference Guide helped families prepare

*See article on page 124.

for travel to the NCR. It was placed on the hospital's web site and included checklists for preparing to leave a household, travel, packing lists, caring for children, and what to expect upon arrival at the facility. The handbook eased a family's transition and allowed them to better support their casualty.

Families are overwhelmed with information upon initial arrival at a medical center and retain little of what they are initially told. They are also significantly affected when they first see their critically injured Warrior in the intensive care unit. These issues were addressed by providing information in writing and repeating it often. Warriors well along in their rehabilitation met with new families and provided encouragement. Seeing a multiple amputee walking on his prostheses provided hope to families during this difficult time. An Integrated Warrior Care Roadmap was developed to show casualties and families the phases and milestones of their recovery. Originally developed by the Marine Corps Wounded Warrior commander, it was refined using length of stay data and tailored to each Warrior based on their injuries. The roadmap allowed families to plan, demonstrated to casualties they were making progress, and gave them events to look forward to, such as convalescent leave. A Nonmedical Attendant/Family Member Advisory Group met monthly with senior JTF CapMed leadership. These meetings kept senior leadership informed of issues and allowed them to discuss progress in resolving them. Monthly town hall meetings with Warriors and families served the same purpose and allowed presentation of information by the many agencies support wounded Warriors.

Regular updates to other interested parties including senior military and civilian leaders, non-Federal entities, the media, and even residents of local neighborhoods were important to the mission. This demonstrated that JTAF CapMed leadership was aware of and were addressing issues, reduced questions, and maintained confidence in the effort.

CONSIDERATIONS FOR THE FUTURE

Two areas of Warrior care require further improvement. First, Warrior Transition Unit, hospital, and installation staff should be provided training in how to support families recovering from the cumulative stress of multiple deployments and rehabilitating from devastating injuries. The second area requiring improvement is the intra-United States medical evacuation system using C-130 aircraft. The vibration, noise, and cold make C-130 medical evacuation flights far less comfortable than those on C-17s. Intra-United States flights on the slower C-130 aircraft are long, as the flight from Joint

Base Andrews to Fort Bragg could take 10 hours with stops at West Point, Fort Drum, Fort Benning, Fort Stewart, and Fort Gordon along the way. Evacuation to the Naval Medical Center, San Diego or Joint Base Lewis McChord could take a week with multiple stops where casualties remained overnight. Army senior leader involvement is required to effect this change with TRANSCOM.

Army Medicine should include the entire continuum of casualty care in the DOTMLPF-P domains and lessons learned process. Casualty care begins in garrison with development of a fit and healthy force, continues in theater and ends in garrison with rehabilitation and reintegration. The collection of lessons learned should not focus only on battlefield care, but include those learned in hospitals, clinics, by support staff, and those crafting policies and programs. Warrior care should be addressed with the same systematic approach as a military operation. Finally, the expertise gained through hard work over years should be sustained by continuing to care for those severely injured rather than referring them to the Department of Veterans Affairs health care system.

The Dole-Shalala Commission noted that making significant improvements in casualty care "requires a sense of urgency and strong leadership. The tendency to make systems too complex and rule-bound must be countered by a new perspective, grounded in an understanding of the importance of patient-centeredness." We must consider this lesson as we prepare for the new challenges ahead.

REFERENCES

1. Priest D, Hull A. Soldiers face neglect, frustration at army's top medical facility. *Washington Post*. February 18, 2007:A01.
2. Priest D, Hull A. Inside the Mologne House, survivors of war wrestle with military bureaucracy and personal demons. *Washington Post*. February 19, 2007:A01.
3. Dole R, Shalala D. *Serve, Support, Simplify: Report of the President's Commission on Care for America's Returning Wounded Warriors*. Washington, DC: July 2007. Available at: http://www.cnas.org/sites/default/files/Dole_Shhalala_July_30_2007report.pdf. Accessed February 22, 2016.
4. West T, Marsh J. *Rebuilding the Trust: Report on Rehabilitative Care and Administrative Processes at Walter Reed Army Medical Center and National Naval Medical Center*. Washington, DC: Independent Review Group. April 2007.

WOUNDED WARRIOR CARE

5. Kizer K, McGowan M, Bowman S. *Achieving World Class: An Independent Review of the Design Plans for the Walter Reed National Military Medical Center and the Fort Belvoir Community Hospital*. May 2009. Available at: <http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA519453>.
6. Ficke JR, Eastridge BJ, Butler FK, et al. Dismounted complex blast injury: report of the Dismounted Complex Blast Injury Task Force. *J Trauma Acute Care Surg*. 2012;73(6suppl5):S520-S532.
7. Pain Management Task Force. Final Report: Providing a Standardized DoD and VHA Vision and Approach to Pain Management to Optimize the Care for Warriors and their Families. Washington, DC: Office of The Army Surgeon General. May 2010.
8. Mateczun J. *Comprehensive Master Plan for the National Capital Region Medical: Creating a World-Class, Integrated Healthcare Delivery System in the National Capital Region*. Washington, DC: Defense Health Board; April 2010.
9. Carino M. Presentation on Emerging Medical Trends. Washington, DC: Office of The Army Surgeon General. Data source: April 2011. Amputee Patient Care Service, WRAMC.

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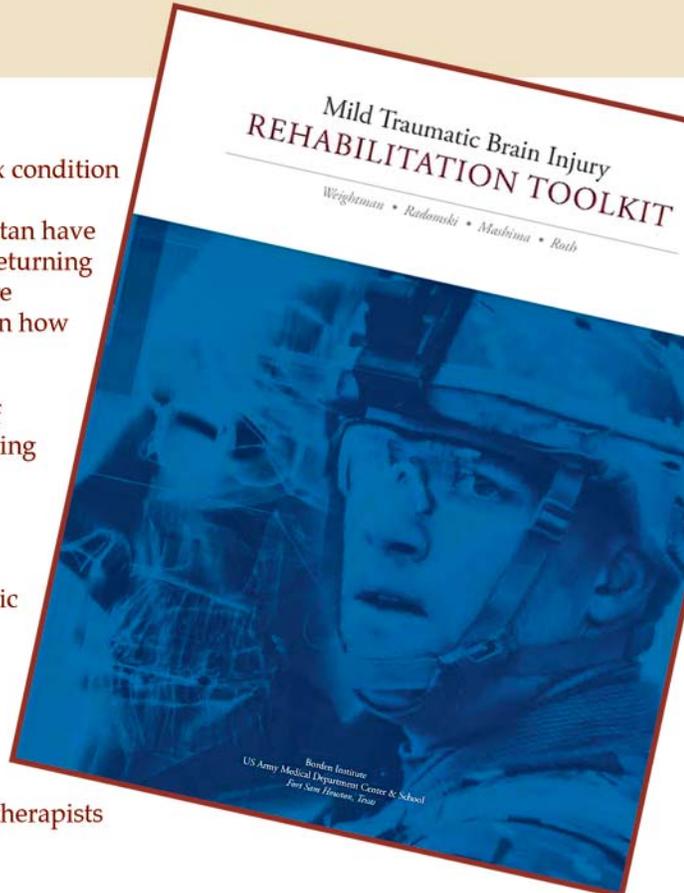
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Traumatic brain injury (TBI) is a complex condition for which limited research exists. The recent conflicts in Iraq and Afghanistan have resulted in numerous service members returning home after sustaining TBI, and healthcare providers scrambling to find resources on how to treat them.

This toolkit is a comprehensive source of inventories and therapy options for treating service members with mild TBI.

All aspects of mild TBI are covered, including vestibular disorders, vision impairment, balance issues, posttraumatic headache, temporomandibular dysfunction, cognition, and fitness, among others.

With easy-to-follow treatment options and evaluation instruments, this toolkit is a one-stop resource for clinicians and therapists working with patients with mild TBI.



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Rehabilitation of the Combat Casualty: Lessons Learned from Past and Current Conflicts

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COL (Ret) John C. Shero, MS, USA

ABSTRACT

The field of rehabilitation is deeply rooted in military medicine, especially in promoting the restoration of function and community reintegration of injured service members returning from war. Since military operations began in Iraq and Afghanistan over a decade ago, rehabilitative care programs have been integral in supporting the Military Healthcare System in providing high quality comprehensive care for combat casualties and their families, particularly those with complex blast injuries resulting in conditions such as amputation and other limb dysfunction, traumatic brain injury, and spinal cord injury. Fundamental to a successful rehabilitation program is the coordination of interdisciplinary care that not only crosses multiple medical specialties and disciplines, but also promotes ongoing education, research, quality improvement and readiness. This brief article is intended to highlight some of the most important lessons learned from current and past conflicts in delivering the highest quality rehabilitative care to our nation's heroes.

*As you know, you go to war with the Army you have.
They're not the Army you might want or wish to have
at a later time.*

Secretary of Defense Donald Rumsfeld¹

Although this quote by Secretary Rumsfeld may evoke considerable criticism and debate, more importantly his words should help us focus our attention to make certain that our future fighting forces are well trained, resourced, and equipped to respond to its nation's call for action, whether in peacetime or at war. In order to meet this goal, however, it is critically important that the lessons learned from prior conflicts be preserved, documented, and taught to future generations. Nowhere is this more important than within the Military Healthcare System (MHS), whose fundamental mission is to assure the readiness of its military forces² and to ensure that the existing healthcare system has both the capacity and the competency to ensure that service members and their families receive the highest quality of care. This is particularly true for those who have sustained combat related injuries; or, as President Abraham Lincoln described in his second inaugural address, "to care for him who shall have borne the battle."³ In fact, evidence suggests that independent of what Army you might go to war with, the expectation of the American public is that those men and women who place themselves in harm's way in defense of this nation receive only the highest quality of medical care available.⁴

Over the past decade, tremendous advances have taken place in the acute resuscitative trauma care, changes to

combat medical tactics, techniques, and procedures, and systemic improvements in medical response to battlefield polytrauma, along with the rapid evacuation of combat casualties. Coupled with the protection provided by enhanced body armor, these changes have resulted in historically high survival rates.^{5,6} Mortality rates have been reduced from approximately 24% in the Vietnam conflict to approximately 20% in Operation Iraqi Freedom and Operation Enduring Freedom (OIF/OEF). Survivability of those injured on the battlefield is at an unprecedented historical level of 90%, compared with 84% in Vietnam and 80% in World War II.⁷ Survival on the battlefield, however, is just the first step. The MHS should be committed to not just helping service members "survive" after injury, but to "thrive" as they recover from their wounds and reintegrate with their military units and among family, friends, and communities. This is particularly true for those combat casualties who are challenged with overcoming significant physical, cognitive, or psychological impairments. This capability is especially relevant and important for those who have sustained severe blast injuries, such as those described by the Army Dismounted Complex Blast Injury Task Force.⁸

The term "rehabilitation" can be used in many different contexts, but in healthcare, the term is generally used when discussing the programs or processes for returning an individual to health after an injury, illness, or addiction. More specifically, "rehabilitation medicine" refers to the evaluation, diagnosis, and management of

individuals of all ages with a physical and/or cognitive impairment, to maximize recovery and quality of life. It is through rehabilitation and the restoration of functional independence that many individuals regain dignity and even discover personal growth, which can propel them to discover new meaning and purpose within their lives. Ultimately, rehabilitative efforts are not solely limited to achieving independence or adaptive strategies to promote daily functional activities, but to promote active participation in society and, whenever possible, return to active military service.

The field of Rehabilitation Medicine is deeply rooted in military medicine, especially concerning the restoration of function and community reintegration of injured service members returning from war. Significant advances in the diagnosis and treatment of numerous conditions have largely resulted from rehabilitation programs developed after World Wars I and II. Furthermore, technological advances after Vietnam, particularly in orthotics, prosthetics, and mobility aids have had a profound impact on the care of individuals with limb loss and neuromuscular disorders, not just in the military but also across the globe. Since combat operations began in Iraq and Afghanistan, military medicine has been at the forefront of advancing the knowledge of rehabilitation sciences. As the threat of terrorism continues to be of top priority for the United States, the military and public healthcare systems must be prepared to provide state-of-the-science care to individuals suffering from the acute and chronic effects of terrorist-related injuries.^{9,10}

Although rehabilitative care has been long considered to be the principal responsibility of the Department of Veterans Affairs,¹¹ lessons learned during OIF/OEF and Operation New Dawn (OND) indicate the need for the MHS to maintain competence and capacity in providing rehabilitative care, particularly for combat casualties with complex blast injuries.⁸ Service members exposed to blasts commonly sustain injuries to multiple organ systems. Injuries such as limb loss, soft tissue wounds, paralysis, traumatic brain injury, and vision and/or hearing impairment commonly happen in combination and are frequently also accompanied by complex pain and infection, as well as psychological complications such as depression, anxiety, and posttraumatic stress.¹² It is therefore fundamental to provide aggressive and coordinated care for each of these conditions early in the acute setting, because not addressing these issues immediately may lead to secondary problems and poorer outcomes.¹³⁻¹⁶

Rehabilitative efforts are largely accomplished through the work of an interdisciplinary team of specialists

representing a multitude of disciplines. These specialists employ an array of interventions, modalities, and assistive technologies to help maximize functional independence and successful reintegration or participation in society. Because of the complex nature and spectrum of needs of combat casualties, an expanded list of interdisciplinary team members is required to sustain wartime operations. An example of this list is provided in the Table. In addition, the patient and patient's family are also vital members of the rehabilitative team and remain critical to the successful engagement of rehabilitation throughout the various phases of recovery. An individu-

The Amputee Care Program is dependent upon an interdisciplinary team consisting of many specialties, an example of which is shown below. The specialists and a coordinated team approach are absolutely necessary to provide the highest quality of care and ensure that all needed services are readily available.

Surgery (Access to Subspecialties)	Behavioral Health
Physiatry	Neuropsychology
Infectious Disease	Social Work
Pain Management	Peer Support
Nursing	Nutrition
Physical Therapy	Gait Lab
Occupational Therapy	Database, IT support
Speech Language Pathology	Public Affairs Office
Prosthetics/Orthotics	VA Counselors
Assistive Technology	Vocational Rehabilitation
Sports/Recreational/Art Therapy	Driving Rehabilitation
Physical Evaluation Board Liaison Officer	Integrative Medicine

alized treatment plan can then be established with input from all team members, which addresses the unique characteristics of each patient. This also includes short and long-term goal setting with the team to reinforce treatment objectives, facilitate motivation, and measure outcomes.

Over the course of providing and overseeing rehabilitative care for thousands of combat casualties, the following lessons are offered for the reader to consider in maintaining both competence and capacity for the ongoing and future missions of the MHS.

LESSONS LEARNED

Rehabilitation Must Start in the Acute Care Setting

As reported by COL Paul Brown (MC, USA) regarding his experiences in Vietnam, rehabilitative interventions need to start as early as possible.¹⁷ The paradigm of waiting until all medical and surgical issues are stabilized or resolved before engaging rehabilitative services is fraught with complications and poorer outcomes. This is especially true for casualties with complex blast



Figure 1. A Wounded Warrior recovering from extensive blast injuries. As he underwent multiple reconstructive procedures to save his upper limbs, the specialist team began the extensive rehabilitation for his lower limb amputations.

injuries, where the frequency of multiple comorbid injuries is high. It is well known that there are numerous negative effects of immobility, which early rehabilitation interventions can help mitigate. These negative effects include bone loss leading to osteopenia and osteoporosis, joint contractures which impair mobility and function, metabolic abnormalities, cardiovascular deconditioning, electrolyte and fluid imbalances, orthostatic hypotension, muscle weakness and atrophy, skin breakdown and pressure ulcers, increased risk of infection, poor wound healing, and vascular thrombus formation. In addition to their adverse repercussions on functional

recovery, all of these negative effects are also likely to lengthen hospital stays and subject patients to higher rates of morbidity and mortality. Furthermore, delays in engaging patients in therapeutic interventions to improve independence in activities of daily living, such as self-feeding, bathing, dressing, and toileting, or not assisting patients to be more functionally independent in terms of mobility with a wheelchair, prosthesis, or other assistive device, will likely also have profound negative effects on an injured service member's psychological well-being, motivation, outlook on recovery, and quality of life. Therefore, when designing comprehensive care programs for combat casualties, the simultaneous delivery of state-of-the-science rehabilitative methods is as important as providing advanced medical, surgical, and behavioral health care.^{18,19}

Nowhere is this better illustrated than in the combat casualty who sustains extensive blast injuries, as shown in Figure 1. Combat casualties often sustain multiple injuries, many requiring multiple surgical procedures over a protracted hospital course, during which time each of their associated injuries must be addressed simultaneously, in a coordinated fashion. Surgical reconstruction techniques for vascular, soft-tissue, and nerve repair have dramatically improved over the past decade and offer great hope in restoring function for even the most severely injured service members. Fortunately, the MHS has continued to invest in having some of the most highly trained surgical subspecialists to perform these techniques, not to just save lives, but preserve limbs and function. Their contributions to the care of combat casualties over the past decade have been enormous. Equally important to the mission, however, is the same investment in rehabilitative medicine. As illustrated in Figure 1, while this Wounded Warrior underwent multiple reconstructive procedures to save his upper limbs, our team simultaneously began extensive rehabilitation for his lower limb amputations. This rehabilitation care included preprosthetic education, mobility, and activities of daily living training, core and limb strengthening, range of motion exercises, wound management, residual limb care, and comprehensive pain management. Coupled with these interventions, were appropriate design, fitting, and training for use of his wheelchair and prostheses, followed by extensive training in transfers, standing, balance, level ground ambulation, and eventual training on stairs, ramps, obstacle negotiation, running, and sports participation. All of these interventions happened simultaneously with his upper limb reconstruction and associated upper limb rehabilitation, which included scar management, neuromotor recovery facilitation, muscle strengthening, range of motion exercises, as well as gross and fine motor training to perform functional

activities of daily living. As illustrated in this case, combat casualties with limb loss often experience multiple complex challenges. Evidence suggests, however, that the implementation of a comprehensive rehabilitation care program is effective in improving outcomes.²⁰

Centers of Excellence

While considerable debate may exist over the definition of what composes a “center of excellence,” there is little argument regarding their importance in delivering the highest quality of care to combat casualties. In response to the rehabilitative needs for injured service members from OIF/OEF within the Extremity Trauma and Amputation Center of Excellence (EACE), several advanced rehabilitation centers (ARC) have been established within the DoD system. Their coordinated efforts help support specific geographic regions within the United States in order to provide accessible, highly specialized care to the most complex patients. Given the complexities of the problems encountered by combat casualties, the integrated team includes physicians, nurses, medics, corpsmen, social workers, case managers, behavioral health providers, pain specialists, therapists, prosthetists, orthotists, technicians, plastic surgeons, dermatologists, ophthalmologists, audiologists, pharmacists, and dentists across numerous disciplines who must collaborate to provide interdisciplinary care. In addition to healthcare providers, numerous support structures must be in place within the institution to ensure access to expert intensive critical care and reconstructive surgery; highly specialized diagnostics; 3D printing and fabrication; state-of-the-art prosthetic and orthotic fitting and adjustment; computer assistive accessibility for patients with vision, hearing, or extremity impairment; interventional pain suites to apply novel interventions for complex pain syndromes; highly sophisticated gait, motion analysis, and virtual reality platforms; as well as access to complementary and alternative medicine. Of equal importance to having trained and experienced providers with cutting edge technology is having engaged and effective leadership teams with supportive administrative staff. Unless the providers are resourced and supported appropriately by their leadership, efficient and effective care cannot be delivered. Issues such as infection control policies, efficient scheduling of operating rooms, logistical support to ensure supplies are delivered on time, along with timely and efficient provider privileging and credentialing are all critical functions of the leadership within military treatment facilities (MTF). Facilitating these actions is a well-coordinated performance/quality improvement program. Having a mechanism where the members of the interdisciplinary team and leadership can meet regularly to critically evaluate what processes and interventions work well and which should be improved can greatly

enhance the effectiveness and efficiency of the care program. Ongoing performance/quality improvement programs are increasingly important during times of war, especially when the MTF experiences frequent staff turnover along with a continuous influx of casualties.

The importance of having access to highly specialized care cannot be overstated. The advanced rehabilitation centers and other centers of excellence in the MHS provide an environment for bringing specialists together and allowing them to work in a coordinated fashion, while also further developing their skills through collaborative experience. This can only be achieved by caring for a high volume of patients with similar complex problems. It must also be recognized that the complex set of problems commonly encountered by Wounded Warriors with limb loss and their families are unique and not often seen in civilian settings. For example, nearly all amputations that are performed in the United States in both civilian and Veteran Affairs affiliated hospitals are the result of vascular disease and/or diabetes, not from blast injuries. Further, most amputations performed in civilian hospitals are to the lower limb below the knee, whereas among our military amputee population, a significant percentage of combat casualties sustained upper limb ($\approx 20\%$), multiple limb ($\approx 30\%$), and above knee ($\approx 40\%$) amputations.²¹ Combat casualties with limb loss are also generally younger than their civilian counterparts, and the mechanism of blast injuries makes them more prone to develop complications, such as heterotopic ossification ($\approx 60\%$)²² as well as comorbid brain injury and psychological stress. In summary, the medical, surgical, rehabilitative, and behavioral health care needs of combat casualties are different than those generally seen in civilian practice, so without having centers of excellence within the MHS, expertise in their unique care requirements would not otherwise exist.

Centers of excellence bring medical experts together, as well as patients, families, and often former patients who serve as peer mentors. This construct is enormously powerful in promoting healing, recovery, and quality of life. There are tremendous benefits in the development of a therapeutic milieu for a group of Wounded Warriors going through their rehabilitation, recovery, and reintegration as a team. Military service members are trained to be part of a unit and function as a member of a team. After injury, they are taken from their combat team through medical evacuation and now must join another team—a team motivated to recover and rejoin the fight. Serving as a peer mentor allows team membership to continue, even after discharge. Our collective experiences during OIF, OEF, and OND within the MHS’s Advanced Rehabilitation Centers at Walter

Reed National Military Medical Center (WRNMMC) in Bethesda Maryland, the Center for the Intrepid (CFI) in San Antonio, Texas, and the Comprehensive Combat and Complex Casualty Care (C5) program in San Diego, California, demonstrate the positive effect of having combat casualties who have successfully completed the program return to motivate others to do the same. Peer mentors motivate fellow Wounded Warriors throughout their rehabilitation. This is a very effective method of proving to those still in rehabilitation that there is life after injury and that they can also achieve great success, no matter what the challenge. Evidence supports this approach, as graduates of the program have consistently lauded their care and specifically described the peer support that they received as beneficial.²³

Role of Families and Nonmedical Attendants

Differentiating the MHS from the Veteran's Healthcare Administration and other civilian healthcare organizations is the Department of Defense's ability and authority to provide comprehensive care for the families of Wounded Warriors, independent of geographical boundaries. During OIF, OEF, and OND, DoD policy changed to allow family members or other designated nonmedical attendants (NMAs) to stay on the campus of MTFs, as well as receive a stipend to offset the cost of their missing work to stay by the side of their Wounded Warrior to assist them through their recovery. This unprecedented practice has had an enormously positive effect on the rehabilitation of Wounded Warriors. As previously reported in caring for Vietnam Veterans,¹⁴ promoting independence is critical to successful rehabilitation. Creating situations where an injured service member becomes dependent on a loved one for basic functions, such as feeding, dressing, and hygiene, can have a negative effect on self-esteem and motivation. While therapists work daily with patients to teach and train independent skills, reinforcement by family members during times when the patient is not in therapy can greatly enhance the effectiveness of rehabilitation. Having family members or NMAs participate in rehabilitation sessions with the Wounded Warrior has had substantial benefits. In addition, the importance of the support and love for the Wounded Warrior during an incredibly emotionally challenging time cannot be underestimated.

Access to Technology

A comprehensive discussion of all the technological advances that are currently available for Wounded Warrior care is beyond the scope of this article. In support of rehabilitation, however, the technological advances in diagnosis, therapeutics, and functional independence have been tremendous, even over the past decade. Advances in prosthetic sockets and components, such as computer

controlled knees, ankles, and hands allow much greater functionality for individuals with limb loss. Microprocessor controlled variable dampening prosthetic knees (Figure 2) are able to sense how fast an individual is walking and adjust knee stiffness during stance and swing



Figure 2. Microprocessor controlled variable dampening prosthetic knees are able to sense how fast an individual is walking and adjust knee stiffness during stance and swing phases of gait nearly instantaneously to accommodate a variable cadence.



Figure 3. Specialized motorized wheelchairs enable even those with severe physical impairments to more independently perform pressure reliefs, stand, transfer, and control.

phases of gait nearly instantaneously to accommodate a variable cadence. Lighter weight materials allow service members to have access to ultralight, high performance wheelchairs that have been shown to reduce secondary problems, such as overuse shoulder, elbow, wrist, and hand injuries. Furthermore, currently available specialized motorized wheelchairs (Figure 3) enable even those with severe physical impairments to more independently perform pressure reliefs, stand, transfer, and control. Computer interfaces, tablet devices, and other technologies create greater opportunities for those with vision and hearing loss to communicate. Three-dimensional printing enhances reconstruction procedures for fabrication of customized devices for adaptive equipment. Finally, advances in virtual reality and simulation platforms create even more opportunities to enhance our diagnostic and therapeutic rehabilitative interventions.²⁴

Clarifying Roles and Relationships Between the DoD and Department of Veterans Affairs

Meeting the rehabilitative needs of injured service members during a time of war is not only a challenge to the DoD, but a challenge for the nation. Therefore, a strong partnership with the Department of Veterans Affairs (VA) as well as civilian organizations is important to expand the capacity of care for Wounded Warriors, particularly during a protracted war or when there is a high volume of casualties. Although expertise in various areas of rehabilitative medicine exists within civilian care settings, the DoD and VA are specifically resourced and trained to care for the complex issues pertaining to service members and Veterans. Understanding each other's roles can help clarify patient movement within the 2 systems, as well as improve access to care and enhance efficiencies in care delivery through resource sharing agreements. Finally, sharing lessons learned and partnership in education and research can act as a tremendous force multiplier. An example of this has been the partnership between WRNMMC, the Uniformed Services University of the Health Sciences and the Human Engineering Research Laboratories within the VA Pittsburgh Healthcare System. These entities have partnered to present quarterly state-of-the-science workshops over the past 10 years, bringing nationally recognized experts in all aspects of rehabilitative medicine and science to share experiences and new discoveries to elevate the care of service members, families, and Veterans. Similar workshops and educational experiences have been organized by many other joint efforts between the DoD and VA, including those coordinated by the Defense and Veterans Brain Injury Center, Center for Integrated Pain Management, EACE, Vision and Hearing Centers of Excellence, and others.

While a detailed description of all the programs that exist between the DoD and VA in providing healthcare services for Wounded Warriors is beyond the scope of this article, several are worth noting. Of significant importance is the relationship that exists between the designated 5 Polytrauma Rehabilitative Centers within the VA system and those within the DoD system (WRNMMC, CFI, and C5). In combination, these 8 complex patient care programs are distributed geographically throughout the United States and improve access to high quality care for combat casualties independent of the location of their home of record or duty station. Coordinating patient transfers from one facility to another is facilitated by embedded DoD and VA liaisons at each of these centers. Coordination between the 2 systems better meets the acute, subacute, and chronic care needs of Wounded Warriors, whether they remain on active duty or retire. To better facilitate patient movement between the DoD and VA systems, additional work is still needed to improve the interoperability between the 2 clinical information technology systems. This would significantly enhance sharing of medical records, especially radiographic, laboratory, and pharmacy information. Throughout OIF, OEF, and OND, numerous service members and Veterans have moved back and forth between DoD and VA healthcare organizations. Sharing electronic medical records is important not only to facilitate continuity of care, but also to enhance patient safety.

Another important aspect of caring for combat casualties is navigating the medical disability process. Many injured service members remain on active duty after completing their rehabilitation. Many of these Wounded Warriors undergo medical review board evaluations to determine if they meet military medical retention standards. If they do, they return to duty status, although it may be with limitations due to permanent physical disabilities. For those who do not meet military medical retention standards, they may apply for a Continuation on Active Duty or Continuation on Active Reserves waiver, which would allow them to remain on active duty despite their medically disqualifying injury or disease. Unfortunately, there remains a cohort of Wounded Warriors who will be medically separated from the military, even though they would prefer to continue to serve. For these men and women, a system should be in place to conduct disability evaluations and compensation ratings in a manner that is both comprehensive and expeditious. Sharing resources between the DoD and VA is critical to accomplish this challenging mission. Medical compensation and life-long access to continued medical care for injuries sustained during war are important elements of the trust established between the

nation and our volunteer military force. Since the majority of injured service members who go through the medical evaluation board (MEB) process are also actively engaged in rehabilitative services, rehabilitation professionals must be aware of the process and provide pertinent information to the patient and MEB providers. Because of the potential for perceived conflict of interest, providers who are intimately involved with treating patients should not also be involved in the adjudication of medical compensation decisions. Lessons learned over the past decade indicate that independent providers should fulfil this role within both the DoD and VA systems. Ideally, an integrated disability and compensation system should be established between the DoD and VA systems, with clear roles and responsibilities delineated to avoid confusion for providers and patients.

Promote Reintegration and Community Participation

A key aspect of recovery after war injury is returning to active participation. The term “participation” may mean different things to different people, but has been highlighted by the World Health Organization as an important aspect of International Classification of Functioning, Disability and Health. Essentially it recognizes that quality of life is often dependent on an individual’s ability to be an active participant in society, either through vocation, avocation, volunteer work, or engagement with family and friends. Limitations to participation include such issues as a “nonaccessible” community with barriers to mobility, poor transportation systems, lack of communication aids or provisions for those with vision or hearing loss, as well as limited access to rehabilitative services. These issues become very relevant in caring for Wounded Warriors, particularly those with multiple complex injuries and resultant impairments. Therefore, active community reintegration programs are needed to care for combat casualties and should be well coordinated between the DoD and VA systems. Over the past decade, many of these programs were developed within the DoD system to meet the demands of our Wounded Warriors and their families. While it is clear that these services are a shared responsibility of both the DoD and VA, experience suggests the importance of their ongoing presence within the DoD system.

Peer support, adaptive sports and recreation, creative arts, and service dog programs have all been critical elements for many Wounded Warriors during their first steps towards successful community reintegration. These programs not only build opportunities for socialization and initial transition out of the hospital, but greatly facilitate confidence building, motivation, and improved self-efficacy, which are fundamental to the successful rehabilitation and recovery of injured

service members. Disfiguring wounds, impaired mobility, psychological injuries (eg, posttraumatic stress, depression, anxiety) and loss of many normal bodily functions are extremely challenging for young service members, independent of their gender, race, or ethnic diversity. Therefore, programs that promote activities to help overcome these challenges continue to prove beneficial in Wounded Warrior care. In fact, many of the national and international disabled athletic programs, adaptive sports and recreational activities, or great art contributions, have come from the efforts of Veterans of current or prior wars.

Similar to sports, creative arts, or other activity programs, Driving and Vocational Rehabilitation services are also fundamental for improving ultimate community participation for recovering Wounded Warriors. Adaptive devices for improving accessibility and independence in driving are often cited by many Wounded Warriors as one of the most important aspects of their care. The ability to drive decreases social isolation, promotes vocational and active life-roles within the community, and improves access to care for patients who need to return to medical facilities for ongoing rehabilitation, wellness visits, or complications that may arise. Vocational rehabilitation is also important and should be conducted by trained professionals who are skilled at both counseling and evaluating Wounded Warriors based on their interests, talents, and abilities. Vocational opportunities may include retraining, additional schooling, internships, or job placement with the appropriate adaptive devices or accommodations established to ensure success. Vocational rehabilitation counselors are not solely focused on finding a job for Wounded Warriors, but helping Wounded Warriors find a career path that will be sustainable as well as professionally fulfilling.

Finally, programs such as Project C.A.R.E.* (Comprehensive Aesthetic Restorative Effort) at Naval Medical Center San Diego (NMCS D) provide state of the art multidisciplinary medical and surgical care designed to reconstruct complex wounds, improve appearance, and enhance emotional recovery after trauma. The CARE Program is a highly specialized team of “restorative” disciplines including plastic surgery, dermatology, oral surgery, oculoplastic surgery, facial plastic surgery, and orthopaedic hand surgery. Together, they augment the MTF rehabilitation program by finding advanced solutions for the most severely injured Wounded Warriors. In addition to coordinating care and providing emotional support for patients and their families, the CARE team helps advance the art and science of restorative care

*<http://www.med.navy.mil/sites/nmcsd/Pages/Services/Project-C-A-R-E.aspx>

through education, training, and research. This includes collaborating with civilian Centers of Excellence to facilitate hand and face transplantation, along with hosting an annual educational summit featuring military and civilian experts from around the world specializing in advanced prosthetics, tissue engineering, regenerative medicine, and other emerging technologies. The CARE Program at NMCS D is a cutting edge initiative, serving to break down recovery barriers and expedite the return of optimal form, function, and emotional wellbeing after injury to remove the final barriers for Wounded Warriors to return to full community participation.

Ongoing Education and Research

Military medicine has a long-standing tradition in medical education and cutting edge research. To sustain war-related combat casualty care for current and future conflicts, ongoing educational programs are necessary to meet competency and capacity demands, as well as for building tomorrow's leaders of military medicine. Educational programs should support the entire spectrum of medical specialties and disciplines, ranging from the combat medic to highly specialized nurses, dentists, physicians, and therapists. These educational programs must address the unique and specific needs of the military through designated specialized curricula. Ongoing educational activities are important for staff within military treatment facilities, either within or outside the continental United States. Issues such as provider recruitment and retention must be continually assessed by leaders to ensure current and future capacity needs are met. Moreover, care and attention must be available for our caregivers. The stress of caring for Wounded Warriors, while also balancing one's own physical, psychological, and emotional health, can be extremely challenging. It should also be recognized that most of the healthcare providers in uniform are also frequently deployed overseas during war, which only further contributes to the likelihood of excessive stress on caregivers. These factors should be recognized by peers and leaders at the local and national level—support programs can be extremely helpful in maintaining a healthy medical force.

The federal government invests a tremendous amount of resources each year in medical research. Institutes such as the National Science Foundation, National Institutes of Health, and others have been responsible for many breakthroughs in modern medicine and science. However, the DoD and VA also support critical ongoing research with the specific and explicit mission to focus on military and Veteran needs. Institutes such as the Army Medical Research and Materiel Command, Naval Medical Research Center, Defense Advanced Projects

Agency, and Walter Reed Army Institute of Research are just some of the examples of DoD's investment in advancing the protection and care of military service members. The efforts of these groups help sustain the military's capabilities to perform both its wartime and peacetime healthcare missions, whether in prevention of disease, mitigation of injury risk, providing life or limb saving interventions on the battlefield, or developing novel prosthetic and orthotic devices.²⁵ These entities collaborate with national and international partners to bring the best technology, equipment, and supplies to the warfighter. A correlate of these efforts is the anticipation of the military's future needs. In terms of rehabilitation, much is already known about the long-term risks of sustaining a combat injury, particularly an injury that results in an amputation.²⁶ Combat casualties with limb loss are at much greater risk for early morbidity and mortality, whether related to cardiovascular disease, diabetes, bone health, arthritis, or overuse injuries. Research efforts must therefore address the long-term medical challenges of caring for individuals with combat-related injury, by both mitigating their risks as well as discovering novel treatments. Regenerative medicine, robotics, neural-prosthetics, personalized medicine, and advanced diagnostics are just some examples of current fields of study in which investment will likely have an enormous impact on the future of healthcare. Given the relatively young age of our current Veterans from Iraq and Afghanistan, technologies that may be 20, 30, or even 40 years away from clinical implementation would still have a significant impact on their health and well-being.

Embrace and Harness Public Support

Unlike prior reports from the Vietnam era, during the current conflicts the American public has been able to separate their political views of war from the injured Warrior. Over the last decade of treating combat casualties from OIF, OEF, and OND, our staff has not encountered anyone in our private or professional lives who was not sensitive to and supportive of the needs of our Wounded Warriors. Currently there are numerous federal and state-sponsored programs, as well as countless nonprofit organizations that have been established to help Wounded Warriors. Despite this, however, enormous challenges still exist for individuals with disabilities (military and civilian) to obtain the same access to care, technologies, or employment as their able-bodied counterparts. Part of the challenge, therefore, is finding ways to increase awareness of the support programs that currently exist for those in need. Many nonprofit groups and private donors are well-positioned to help enhance care programs for Wounded Warriors. While their support should be embraced, it cannot happen without local

leaders establishing policies and procedures to ensure that all legal requirements are met. Issues such as a perceived DoD endorsement of one private organization over another create significant challenges for personnel trying to coordinate Wounded Warrior care. While these challenges may be substantial, the benefits regularly outweigh the risks.

In addition, given the public's interest in our Wounded Warrior needs, frequent media requests are often made to MTFs and providers. Department of Defense providers must be reminded that their words or actions represent the overall institution, not just themselves. Therefore, a skilled public affairs office/officer should be part of the staff of any MTF responsible for caring for Wounded Warriors. While managing all media invitations/requests may be overwhelming and challenging, in general they should be embraced by the DoD. Media requests should be treated as part of the constant effort to improve awareness of the challenges Wounded Warriors face, and also as an inspiration and demonstration to the nation and our allies of the incredible courage, spirit, and resilience of our Nation's Heroes.

REFERENCES

1. Kristol W. The Defense Secretary we have. *Washington Post*. December 15, 2004;A33.
2. Evans P. Strategy Management in the Military Health System: Achieving the Quadruple Aim. Washington, DC: Office of Strategy Management, Office of the Assistant Secretary of Defense for Health Affairs; 27 July 2010. Available at: https://www.meprs.info/files/2010_presentations/Quadruple_Aim.ppt. Accessed February 29, 2016.
3. Lincoln A. Second Inaugural Address of Abraham Lincoln. New Haven, CT: Lillian Goldman Law Library, Yale University; March 4, 1865. Available at: http://avalon.law.yale.edu/19th_century/lincoln2.asp. Accessed February 29, 2016.
4. Burgess L, Shane L. Army Secretary Francis J. Harvey resigns amid Walter Reed fallout. *Stars and Stripes*. March 2, 2007.
5. Gerhardt R, De Lorenzo R, Oliver J, Holcomb J, Pfaff J. Out-of-hospital combat casualty care in the current war in Iraq. *Ann Emerg Med*. 2009;53:169-174.
6. Ling G, Rhee P, Ecklund J. Surgical innovations arising from the Iraq and Afghanistan Wars. *Annu Rev Med*. 2010;61:457-468.
7. Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF. Understanding combat casualty care statistics. *J Trauma*. 2006;60:397-401.
8. Carvalho J. *Dismounted Complex Blast Injury Report of the Army Dismounted Complex Blast Injury Task Force*. Fort Sam Houston, TX: The Army Surgeon General; June 18, 2011.
9. Foster D. Preparing for the next terrorist attack in America [internet]. American Military University; October 1, 2015. Available at: <http://in homeland security.com/preparing-for-the-next-terrorist-attack-in-america/>. Accessed November 15, 2015.
10. Pasquina PF, Scoville CR, Belnap B, Cooper RA. Introduction: developing a system of care for the combat amputee. In: Lenhart MK, ed-in-chief. *Textbook of Military Medicine: Care of the Combat Amputee*. Washington, DC: Borden Institute, 2009:1-18.
11. MacLennan D, Clausen S, Pagel N, Avery JD, Sigford B, MacLennan D, Mahowald R. Developing a polytrauma rehabilitation center: a pioneer experience in building, staffing, and training. *Rehabil Nurs*. 2008;33:198-204, 213.
12. Reiber G, McFarland L, Hubbard S, et al. Servicemembers and veterans with major traumatic limb loss from Vietnam war and OIF/OEF conflicts: Survey methods, participants, and summary findings. *J Rehabil Res Dev*. 2010;47:275.
13. Mackay LE, Bernstein BA, Chapman PE, Morgan AS, Milazzo LS. Early intervention in severe head injury: long-term benefits of a formalized program. *Arch Phys Med Rehabil*. 1992;73:635-641.
14. Semlyen JK, Summers SJ, Barnes MP. Traumatic brain injury: efficacy of multidisciplinary rehabilitation. *Arch Phys Med Rehabil*. 1998;79:678-83.
15. Pezzin L, Dillingham T, MacKenzie E, Ephraim P, Rossbach P. Use and satisfaction with prosthetic limb devices and related services. *Arch Phys Med Rehabil*. 2004;85:723-729.
16. McFarland L, Winkler S, Heinemann A, Jones M, Esquenazi A. Unilateral upper-limb loss: satisfaction and prosthetic-device use in veterans and servicemembers from Vietnam and OIF/OEF conflicts. *J Rehabil Res Dev*. 2010;47:299.
17. Brown P. Rehabilitation of the combat-wounded amputee. In: Burkhalter WE, Ballard A, eds. *Orthopedic Surgery in Vietnam*. Washington, DC: Department of the Army, Office of the Surgeon General and Center for Military History; 1994:189-209.
18. Pasquina P. Optimizing care for combat amputees: experiences at Walter Reed Army Medical Center. *J Rehabil Res Dev*. 2004;41(3B):vii-xii.
19. Sayer NA, Cifu DX, McNamee S, Chiros CE, Sigford BJ, Scott S, Lew HL. Rehabilitation needs of combat-injured service members admitted to the VA polytrauma rehabilitation centers: the role of PM&R in the care of wounded warriors. *PM R*. 2009;1:23-28.

WOUNDED WARRIOR CARE

20. Doukas WC, Hayda R, Frisch HM, et al. The Military Extremity Trauma Amputation/Limb Salvage (METALS) Study: Outcomes of amputation versus limb salvage following major lower-extremity trauma. *J Bone Joint Surg*. 2013;95:138-145.
21. Extremity Trauma and Amputation Center of Excellence. Washington, DC: Department of Veterans Affairs and Department of Defense; 2015. Available at: <http://www.health.mil/About-MHS/Other-MHS-Organizations/Extremity-Trauma-and-Amputation-Center-of-Excellence>.
22. Potter BK, Burns TC, Lacap AP, Granville RR, Gajewski DA. Heterotopic ossification following traumatic and combat-related amputations: prevalence, risk factors, and preliminary results of excision. *J Bone Joint Surg Am*. 2007;89:476-486.
23. Pasquina PF, Tsao JW, Collins DM, Chan BL, Charrow A, Karmarkar AM, Cooper RA. Quality of medical care provided to service members with combat-related limb amputations: report of patient satisfaction. *J Rehabil Res Dev*. 2008;45(7):953-960.
24. Isaacson BM, Swanson TM, Pasquina PF. The use of a computer-assisted rehabilitation environment (CAREN) for enhancing wounded warrior rehabilitation regimens. *J Spinal Cord Med*. 2013;36:296-299.
25. Rasmussen TE, Rauch TM, Hack DC. Military trauma research: answering the call. Preface. *J Trauma Acute Care Surg*. 2014;77(3 suppl 2):S55-S56.
26. Robbins CB, Vreeman DJ, Sothmann MS, Wilson SL, Oldridge NB. A review of the long-term health outcomes associated with war-related amputation. *Mil Med*. 2009;174:588-592.

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A US Army Wounded Warrior injured in Iraq and a physical therapist at the Center for the Intrepid participate in the 15th Annual Around the World 5K Run at Lackland Air Force Base, Texas, May 7, 2007. Photo courtesy of the Center for the Intrepid.

Battlefield Documentation of Tactical Combat Casualty Care in Afghanistan

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ABSTRACT

Performance improvement is reliant on information and data, as you cannot improve what you do not measure. The US military went to war in 2001 without an integrated trauma care system to collect and analyze combat casualty care data. By 2006, the conflict in Afghanistan began appreciating the capture and consolidation of hospital care documentation into the Department of Defense Trauma Registry. In contrast, a paucity of documentation has existed for prehospital or tactical combat casualty care (TCCC). Using the 75th Ranger casualty documentation model established in 2005, the Joint Trauma System developed a casualty data collection system for prehospital care using the TCCC Card, the TCCC After Action Report (AAR), and the Prehospital Trauma Registry. In 2013, this system was mandated for use by US forces in Afghanistan. The Joint Trauma System also created and deployed a prehospital team to be an integral part of the Joint Theater Trauma System in Afghanistan. This prehospital team provided prehospital training and facilitated prehospital data capture. Described and analyzed in this report are prehospital data captured in Afghanistan from 2013 to 2014 using the TCCC Card and the TCCC AAR.

BACKGROUND

In 2006, the Joint Trauma System (JTS) established the Joint Theater Trauma System (JTTS) in Afghanistan with a hospital data collection system and a database (formerly the Joint Theater Trauma Registry, now the Department of Defense Trauma Registry), that was specifically designed to capture, consolidate, and analyze combat casualty care provided in deployed military hospitals (eg, combat support hospital). Data from this registry have subsequently produced evidence-based performance improvement recommendations that have optimized clinical practice guidelines, supported equipment and supply requirements, and ultimately advanced emergency and surgical care for severely and critically injured combat casualties. Throughout this process, there have been 44 JTS clinical practice guidelines developed to improve care for combat casualties.¹ These efforts have contributed to survival rates as high as 98% for those arriving alive at military hospitals in Afghanistan,² however, it has been both tactical and medical efforts that have significantly contributed to the reduction of case fatality rate to less than 10% for the entire conflict.³

helicopter transport have also benefitted from the availability of adequate data, particularly inflight casualty care data. Notable was the study by Mabry and colleagues⁴ that demonstrated survival benefit in casualties who were transported and treated by critical care flight paramedics as compared to basic flight medics. As a result of this study, the US Army adopted the critical care flight paramedic as a standard for prehospital helicopter transport, and provided the commensurate funding, support, and training required to achieve this level of expertise. Additionally, inflight blood transfusion protocols and capability were made available for prehospital helicopter transport.³ As each prehospital helicopter transport unit developed their own format for documenting inflight care, data points captured would subsequently vary from unit to unit. In response to this issue, the JTS developed and standardized a prehospital transport patient care record (PCR) and after action report (AAR) to improve data captured from inflight casualty care.⁵ The PCR data was then entered into an evacuation care database and also scanned into the patient record on the Theater Medical Data Store (TMDS).

Performance improvement initiatives and implementation of lifesaving interventions during prehospital

During the conflicts in Afghanistan and Iraq, more than 87% of US military combat casualty deaths occurred

during the prehospital phase of care⁶ prior to arriving at a hospital with surgical capability, and it is in this phase of care that casualty care documentation is lacking. By the year 2007, more than 30,000 casualties had already resulted from the conflicts in Iraq and Afghanistan; however, less than 10% of these casualties had adequate prehospital documentation.⁷ Although inherently difficult to capture, this “gap” in documentation was a significant missing link in efforts to optimize combat casualty care. Without this requisite data, those dedicated to improving prehospital care are essentially hunting for solutions while armed with suboptimal evidence.⁷ As more than 24% of prehospital deaths on the battlefield are categorized as “potentially survivable,”^{6,8} prehospital data capture is a must for global performance improvement of combat casualty care.

Having successfully refined its operations in Afghanistan, and having long recognized the gap in prehospital care and documentation, in 2013 the JTS developed and deployed a prehospital directorate for the JTTS in Afghanistan. In addition, novel data collection tools were developed for the capture, consolidation, and analysis of prehospital or Tactical Combat Casualty Care (TCCC).^{1,9-12} These tools included the TCCC Casualty Card, the TCCC After Action Report (AAR), and the Prehospital Trauma Registry (PHTR). All of these products use the MIST (mechanism of injury, injury, signs and symptoms, and treatment) format.

During the tactical field care phase of TCCC, a TCCC Card is completed by the medical or nonmedical first responder and attached to the casualty prior to transport to the next higher role of care. This provides critical treatment information to personnel providing care during transport, and to the medical team receiving the casualty at the hospital. In order to provide documentation of care in the medical record, the TCCC Card was scanned into the patient record on TMDS.

The more comprehensive TCCC AAR was also completed by the first responder and submitted or transmitted to the JTTS within 72 hours of injury. The TCCC AAR has the same basic format and design as the TCCC Card but has more data entry points which provide for a more detailed report for analysis. The TCCC AAR affords the opportunity for senior medical providers to mentor first responders on their prehospital care and to recognize the effect of providing such care in the context of the tactical environment. From a performance improvement perspective, it is absolutely critical to know and understand the tactical situation when interpreting prehospital care documentation. Those who are

experienced in tactical care can optimize feedback and insight. The TCCC AAR was entered into the PHTR, the exclusively performance improvement section was then removed, and only the injury and treatment section was scanned into the patient record on TMDS.

During 2013, JTTS personnel traveled throughout Afghanistan training medical leaders and first responders on the new prehospital documentation system, starting first at main forward operating bases (FOBs) with Role 3 and Role 2 medical treatment facilities, and then to smaller FOBs and combat outposts with only Role 1 personnel. Additionally, the Commander, US Forces–Afghanistan issued Fragmentary Order 13-139* in July 2013 which mandated the use of the TCCC Card and the TCCC AAR for all combat casualties in Afghanistan.

Assessment of adequacy of prehospital care has historically been relatively subjective. We do not know if casualties have received the standard of care in accordance with the TCCC Guidelines at the point of injury. The analysis of data captured in TCCC Cards (Figure 1) and TCCC AARs (Figure 2) permit the initiation of critical performance improvement projects. These performance improvement projects will be presented in this report and will demonstrate the value of data capture and analysis. The JTTS prehospital team evaluated compliance with documentation and use of the TCCC Card and TCCC AAR. This team also provided “near real time” performance improvement feedback and recommendations to unit commanders, medical leaders, and first responders using PHTR (Figure 3) data and analysis. This report describes those initiatives.

PERFORMANCE IMPROVEMENT PROJECT ONE

Methods

From July 1, 2013, to March 31, 2014, the patient records of all US military qualified casualties were reviewed on TMDS for a TCCC card. The US Central Command Commander’s Daily Casualty Report was used to provide accurate casualty counts. Trauma casualties evacuated from prehospital to hospital care (from Role 1 to a Role 2 or Role 3) qualified for TCCC Cards, TCCC AARS, and entry into the PHTR.

All qualified TCCC Cards were categorized as legible if greater than 80% of the card could be read and understood. The number of data fields completed on the TCCC Card gave a percentage for completeness. Additionally, casualties evacuated out of theater were compared to their respective TCCC Card annotated evacuation precedence; “urgent,” “priority,” and “routine.”

THE ARMY MEDICAL DEPARTMENT JOURNAL

TACTICAL COMBAT CASUALTY CARE (TCCC) CARD

BATTLE ROSTER #: _____
 EVAC: Urgent Priority Routine

NAME (Last, First): _____ LAST 4: _____
 GENDER: M F DATE (DD-MMM-YY): _____ TIME: _____
 SERVICE: _____ UNIT: _____ ALLERGIES: _____

Mechanism of Injury: (X all that apply)
 Artillery Blunt Burn Fall Grenade GSW IED
 Landmine MVC RPG Other: _____

Injury: (Mark injuries with an X)

TQ: R Arm TYPE: _____ TIME: _____
 TQ: L Arm TYPE: _____ TIME: _____

TQ: R Leg TYPE: _____ TIME: _____
 TQ: L Leg TYPE: _____ TIME: _____

Signs & Symptoms: (Fill in the blank)

Time				
Pulse (Rate & Location)				
Blood Pressure	/	/	/	/
Respiratory Rate				
Pulse Ox % O2 Sat				
AVPU	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Pain Scale (0-10)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

DD Form 1380, JUN 2014 TCCC CARD

BATTLE ROSTER #: _____
 EVAC: Urgent Priority Routine

Treatments: (X all that apply, and fill in the blank) Type _____
 C: TQ- Extremity Junctional Truncal _____
 Dressing- Hemostatic Pressure Other _____
 A: Intact NPA CRIC ET-Tube SGA _____
 B: O2 Needle-D Chest-Tube Chest-Seal _____

C:

	Name	Volume	Route	Time
Fluid			<input type="checkbox"/>	
			<input type="checkbox"/>	
Blood Product			<input type="checkbox"/>	
			<input type="checkbox"/>	

MEDS:

	Name	Dose	Route	Time
Analgesic (e.g., Ketamine, Fentanyl, Morphine)			<input type="checkbox"/>	
			<input type="checkbox"/>	
Antibiotic (e.g., Moxifloxacin, Ertapenem)			<input type="checkbox"/>	
			<input type="checkbox"/>	
Other (e.g., TXA)			<input type="checkbox"/>	
			<input type="checkbox"/>	

OTHER: Combat-Pill-Pack Eye-Shield (R L) Splint
 Hypothermia-Prevention Type: _____

NOTES:

FIRST RESPONDER
 NAME (Last, First): _____ LAST 4: _____

DD Form 1380, JUN 2014 (Back) TCCC CARD

Figure 1. Tactical Combat Casualty Care Card.

Results

A total of 363 US military casualties qualified for TCCC card reporting. Only 7% (24/363) had a TCCC card, of which 96% (23/24) were legible and 88% (21/24) were complete. Of casualties with TCCC cards, 92% (22/24) were battle injuries, and 8% (8/24) were nonbattle injuries (eg, motor vehicle collision). When the 18 casualties who were evacuated out of theater were compared to their respective TCCC card annotated evacuation precedence, it was noted that 72% (13/18) were urgent, 28% (5/18) were priority, and 0% (0/18) were routine.

Comment

Ninety three percent of casualties did not get a TCCC Card. When TCCC Cards are provided, they are generally legible and complete, and first responders are triaging casualties correctly for evacuation.

PERFORMANCE IMPROVEMENT PROJECT TWO
 Methods

Beginning in August of 2013, all qualified TCCC AARs received by the JTTS prehospital team were entered

into the PHTR. For the period October 1, 2013, to April 30, 2014, the PHTR was queried for US casualty TCCC AAR compliance.

Results

Refer to Figure 4. From October 2013 to April 2014, total TCCC AAR compliance was 50% (93/186) with the last 4 months at 84% (57/68).

Comment

Compliance with TCCC AAR submission was directly related to JTTS staff efforts and coordination with the casualty chain of command. During this study time period, the US military initiated retrograde actions for the Afghanistan campaign, and enemy fighting tapered down during the winter months. Both of these factors contributed to a decrease in US military casualties, while JTTS prehospital team efforts and commander involvement most likely accounted for increased compliance with AARs.

PROGRAMMATIC IMPLEMENTATIONS TO IMPROVE HEALTH

FOR OFFICIAL USE ONLY (FOUO)		FOR OFFICIAL USE ONLY (FOUO)	
TCCC AAR (Complete within 72hrs after mission and send via NIPR to the Director of the Joint Theater Trauma System)			
Event Date: _____ Time: _____		Local: [] ZULU: [] Country: _____ Region: []	
Battle Injury (BI): [] WIA / [] KIA / [] DOW		Non-Battle Injury (NBI): [] Alive / [] Dead	
Evacuation Category: [] A / [] B / [] C		Type: _____	
Ground Carry: _____		Type: _____	
Ground Litter: _____		Type: _____	
Ground Vehicle: _____		Type: _____	
Aircraft: _____		Airframe: _____	
Time of Pick Up: _____		Time of Pick Up: _____	
Casualty Demographic Information (Minimum requirement is for Battle Roster # and Unit)			
BR#: _____ Unit: _____			
LName: _____ FName: _____ Rank: _____ SSN: _____ DOB: _____		Last Name: _____ First Name: _____ Rank: _____	
MO - Medical Officer			
M - Mechanism of Injury		I - Injuries	
<input type="checkbox"/> Airborne Operation <input type="checkbox"/> Aircraft Crash <input type="checkbox"/> Blast - Dismounted IED or Mine <input type="checkbox"/> Blast - Mounted IED or Mine <input type="checkbox"/> Blast - RPG or Grenade <input type="checkbox"/> Blast - Indirect Fire (Mortar/Artillery) <input type="checkbox"/> Blast - Other <input type="checkbox"/> Collapse / Crush from Structure <input type="checkbox"/> Environmental: <input type="checkbox"/> Fall, Height: _____ ft <input type="checkbox"/> Fragmentation / Shrapnel <input type="checkbox"/> GSW - Gunshot Wound <input type="checkbox"/> Motor Vehicle Accident <input type="checkbox"/> Other: _____		<input type="checkbox"/> (A)mputation <input type="checkbox"/> (B)leeding <input type="checkbox"/> (B)urn, TBSA: _____ % <input type="checkbox"/> (C)ontusion <input type="checkbox"/> (D)eforimity <input type="checkbox"/> (D)egloving <input type="checkbox"/> (E)cchymosis <input type="checkbox"/> (F)racture <input type="checkbox"/> (G)SW Gun Shot Wound <input type="checkbox"/> (H)ematoma <input type="checkbox"/> (L)aceration <input type="checkbox"/> (P)ain <input type="checkbox"/> (P)Peppering <input type="checkbox"/> (P)Puncture Wound	
S - Signs		Annotate Injuries	
Initial: [] A [] V [] P [] U [] GCS: [] /15 (E) [] /4, V [] /5, M [] /6 RR: _____ HR: _____ BP: _____ / _____ pO ₂ : _____ %			
Last: [] A [] V [] P [] U [] GCS: [] /15 (E) [] /4, V [] /5, M [] /6 RR: _____ HR: _____ BP: _____ / _____ pO ₂ : _____ %			
Eye Opening 4 - spontaneous 3 - to speech 2 - to pain 1 - no response		Verbal Response 5 - alert and oriented 4 - disoriented conversation 3 - speaking but nonsensical 2 - moans, unintelligible sounds 1 - no response	
Motor Response 6 - follows commands 5 - localizes pain 4 - withdraws from pain 3 - decelerate flexion 2 - decelerate extension 1 - no response			
T - Treatments			
WHO		WHAT	
Circulation - Hemorrhage Control		WHERE (on body)	
<input type="checkbox"/> NM [] M [] MO [] TQ-Extremity [] CAT [] SOFTT [] Other: _____ RUE [] LUE [] RLE [] LLE []			
<input type="checkbox"/> NM [] M [] MO [] TQ-Extremity [] CAT [] SOFTT [] Other: _____ RUE [] LUE [] RLE [] LLE []			
<input type="checkbox"/> NM [] M [] MO [] TQ-Extremity [] CAT [] SOFTT [] Other: _____ RUE [] LUE [] RLE [] LLE []			
<input type="checkbox"/> NM [] M [] MO [] TQ-Extremity [] CAT [] SOFTT [] Other: _____ RUE [] LUE [] RLE [] LLE []			
<input type="checkbox"/> NM [] M [] MO [] TQ-Junctional, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] Hemostatic Dressing, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] Pressure Dressing, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] Splint, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] Other: _____			
Airway			
<input type="checkbox"/> NM [] M [] MO [] NPA-Nasopharyngeal Airway			
<input type="checkbox"/> NM [] M [] MO [] Cric-Cricothyroidotomy, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] ET-Endotracheal Tube, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] King LT, [] LMA, [] Other: _____			
DD Form XXXX, 29130311 v1.0		Page 1 of 2	

FOR OFFICIAL USE ONLY (FOUO)		FOR OFFICIAL USE ONLY (FOUO)	
Breathing		Spontaneous [] Labored [] Assisted [] Assisted with BVM [] WHEN	
<input type="checkbox"/> NM [] M [] MO [] Chest Seal, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] Needle Decompression			
<input type="checkbox"/> NM [] M [] MO [] Chest Tube			
Circulation - Resuscitation			
<input type="checkbox"/> NM [] M [] MO [] Saline Lock			
<input type="checkbox"/> NM [] M [] MO [] IO-Intracosseous Device, Type: _____			
<input type="checkbox"/> NM [] M [] MO [] TXA-Tranexamic Acid		Dose: _____	
<input type="checkbox"/> NM [] M [] MO [] Hextend IVF		Volume: _____	
<input type="checkbox"/> NM [] M [] MO [] FDP-Freeze Dried Plasma		Volume: _____	
<input type="checkbox"/> NM [] M [] MO [] Other Blood Product		Volume: _____	
<input type="checkbox"/> NM [] M [] MO [] Other IVF: _____		Volume: _____	
Interventions - Other			
<input type="checkbox"/> NM [] M [] MO [] Eye Shield		[] OD [] OS	
<input type="checkbox"/> NM [] M [] MO [] C-Collar		[] Spine Board	
<input type="checkbox"/> NM [] M [] MO [] Hypothermia Prevention, Product: _____			
<input type="checkbox"/> NM [] M [] MO [] Hypothermia Prevention, Product: _____			
Medications - Pain, Infection, Other (Route = IM, IV, PO, PR, SL, SQ)			
<input type="checkbox"/> NM [] M [] MO [] Combat Wound Pill Pack			
<input type="checkbox"/> NM [] M [] MO [] Analgesic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Analgesic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Analgesic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Analgesic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Antibiotic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Antibiotic, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Other Med, Name: _____		Dose: _____ Route: []	
<input type="checkbox"/> NM [] M [] MO [] Other Med, Name: _____		Dose: _____ Route: []	
General Comments:			
Sustains (Treatment, Equipment, Evacuation, Operations):			
Improves (Treatment, Equipment, Evacuation, Operations):			
BR#: _____		Unit: _____	
DD Form XXXX, 20130311 v1.0		Page 2 of 2	

Figure 2. Tactical Combat Casualty Care After Action Report.

PERFORMANCE IMPROVEMENT PROJECT THREE
Methods

The TCCC guidelines recommend specific analgesia medications—fentanyl, ketamine, and IV morphine—for casualties in moderate to severe pain and do not recommend IM morphine.¹³ As many casualties who incur a gunshot wound or an amputation injury experience moderate to severe pain, from July 2013 to March 2014, the PHTR was queried to assess prehospital pain management in this casualty population within US military forces. Patients who were noted to be “unresponsive” on the AVPU scale were excluded.

Results

Refer to Figure 5. Of 49 casualties who met study criteria, 47% (23/49) did not receive analgesics in the prehospital field setting. Additionally, 14% (7/49) of casualties who received analgesics received IM morphine which is not a recommended medication.

Comment

In contrast to TCCC guidelines, medics continue to be issued and use analgesics that are not recommended.

Prehospital medical directors should issue and train their medics in accordance with current guidelines and standards for prehospital care on the battlefield.

PERFORMANCE IMPROVEMENT PROJECT FOUR
Methods

For hypothermia prevention, the TCCC guidelines recommend the use of the Ready Heat blanket with the heat reflective shell (HRS). To assess compliance with this device, the PHTR was queried from July 2013 to March 2014 identifying US military casualties who were treated with a hypothermia prevention device.

Results

Refer to Figure 6. Of 253 casualties who met study criteria, 51% (129/253) were treated with the Hypothermia Prevention and Management Kit, which contains the Ready Heat blanket with the HRS, and 4% (11/253) were treated using the Ready Heat blanket with the Blizzard blanket. The remaining 45% (113/253) of casualties were treated through improvised measures and did not receive the heat producing Ready Heat blanket.

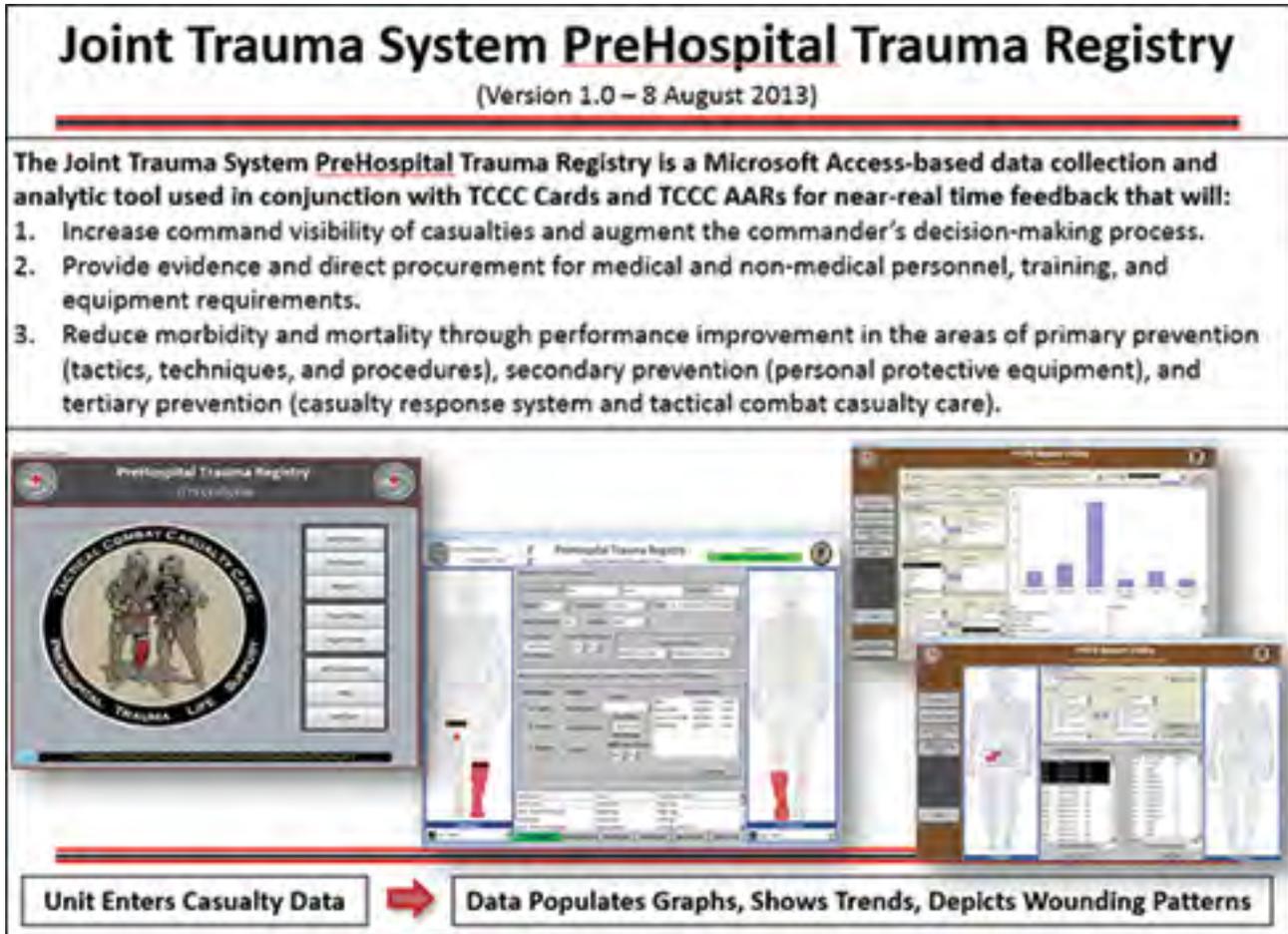


Figure 3. Joint Trauma System prehospital trauma registry.

Comment

Hypothermia in combination with coagulopathy and acidosis is designated the “lethal triad.” Blood loss can significantly affect a patient’s ability to generate body heat, especially in the stressful combat environment. The TCCC guidelines recommend the use of the Ready Heat blanket with the HRS for combat casualties, and it should be made accessible during combat operations when possible.

PERFORMANCE IMPROVEMENT PROJECT FIVE

Methods

Eastridge and colleagues⁶ identified 19% of potentially survivable prehospital deaths were due to junctional hemorrhage. Between January 1, 2013, and March 22, 2014, 541 casualties were entered into the PHTR. The PHTR provided insight into the use of junctional tourniquets in the field.

Results

The data from the PHTR query showed that 178 casualties had either been injured in the junctional region

or did not have adequate control of extremity hemorrhage after application of a tourniquet. Nineteen of these 178 casualties required a massive transfusion. To ensure other sources of hemorrhage were not the source of blood loss, casualties with injuries to other body regions (6 patients) were excluded. This left a cohort of 13 patients who demonstrated the potential need for a junctional tourniquet. In this group of 13 patients, only one (7%) was managed with a junctional tourniquet.¹⁴

Comment

Although the investigators could not quantitate the specific number, several of the casualties received care at locations that did not have junctional tourniquets available. Subsequently, the Army added a junctional tourniquet to medical sets.

GENERAL COMMENT

A survey conducted by Sauer and colleagues² in Afghanistan in 2013 showed that deployed US military personnel confirmed that they had received predeployment training, including TCCC card training: 88% of

PROGRAMMATIC IMPLEMENTATIONS TO IMPROVE HEALTH

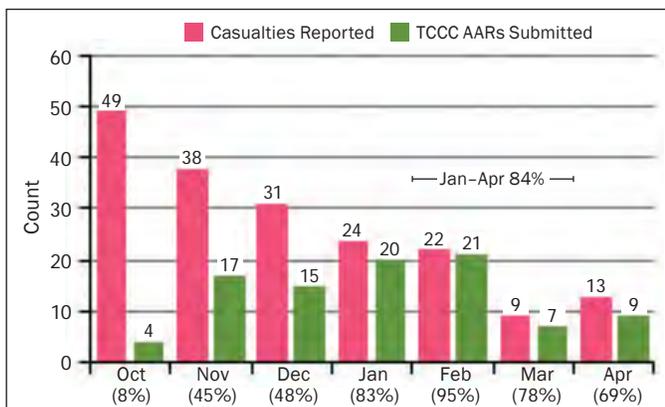


Figure 4. Tactical Combat Casualty Care After Action Report compliance; October 2013–April 2014.

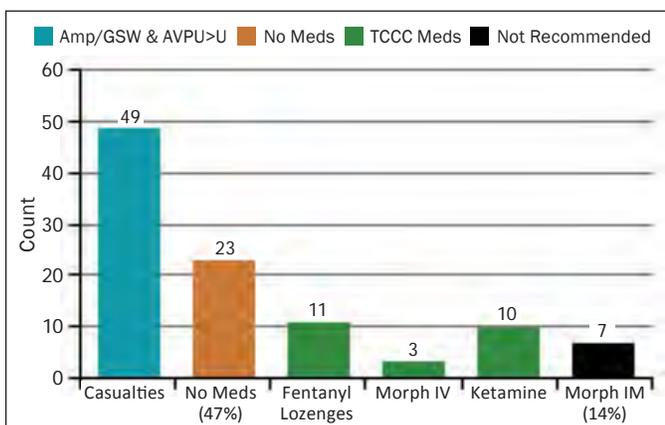


Figure 5. Analgesia administered to amputation or gunshot would casualties not unconscious; July 2013–March 2014.

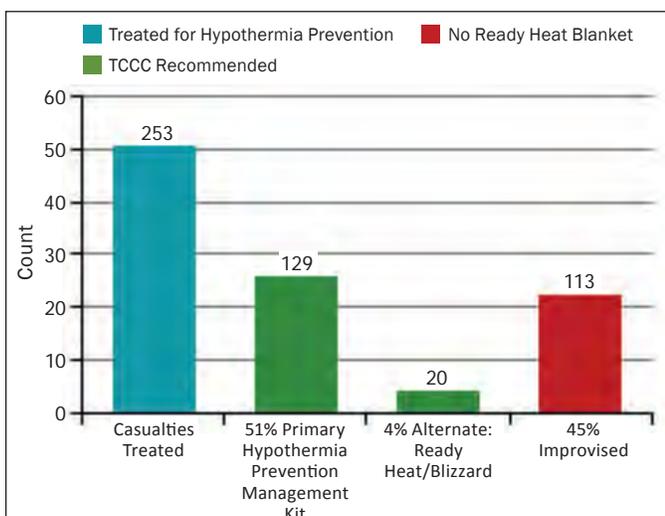


Figure 6. Hypothermia prevention using Tactical Combat Casualty Care recommended Ready Heat Blanket; July 2013–March 2014.

nonmedics had attended the Combat Lifesaver (CLS) course; 88% of medics had completed Brigade Combat Team Trauma Training, and 69% of medical officers had completed the Tactical Combat Medical Course or Combat Casualty Care Course. Additionally, 92% of US military personnel carried an Individual First Aid Kit containing a TCCC card which is usually prefilled with the service member's name, unit, and battle roster number as per unit standard operating procedure. The Commander, US Forces–Afghanistan issued an order in July 2013 directing the documentation of prehospital casualty care using the TCCC card and the TCCC AAR. However, even with trained end-users, TCCC card availability, and an order issued by the senior commander in Afghanistan, after 9 months the JTTS prehospital team still reported only 7% of prehospital casualty care had been documented to the patient record on a TCCC card. The missing element was leadership enforcement of the mandate.

McGarry and colleagues¹⁵ conducted a study on whether there was a training deficiency on using the TCCC Card by military medical providers at the Tactical Combat Medical Course (TCMC) course. Their study, conducted between January and April of 2013, demonstrated the contrary as their results showed prehospital medical documentation compliance of 99% (130 cards for 131 manikins) and accuracy of information of 83% (1300 of 1560 fields completed correctly).

Over a 2-year period, 60 midlevel and senior US Army Medical Department and Department of Defense medical trainers, many of whom were senior noncommissioned officers (NCO) with prior combat deployments as a front-line medic, were approached and asked why TCCC cards were not being used for prehospital documentation.* These medical trainers reported that the tactical situation—multiple casualties, rapid helicopter transport times, the need to complete the mission—was the main reason for the lack of documentation. The TCCC card was otherwise not considered a treatment priority as it does not directly contribute to saving a casualty's life. Many of those interviewed also acknowledged that TCCC card completion is not an enforced or reportable event. As there are no consequences if the card is not completed, many also admitted to not even attempting to fill out the card during prehospital care.

*Author J. B. Robinson: conversations with NCO Instructors at the AMEDD Advance Leaders Course, Ft Sam Houston, TX, June 2014; Combat Casualty Care Course Instructor Course, Camp Bullis, TX, August 2014; 32D Medical Brigade Training Support Company Best Medic competition rehearsals at Camp Bullis, TX, October 2014; Brigade Combat Team Trauma Training at Camp Bullis TX, March 2015; Soldier Medic Training Site, Camp Bullis, TX, May to September 2014.

There is no standard location or recommendation for TCCC Card attachment to the combat casualty. TCCC Card placement is left to the discretion of the individual units and thus will vary from unit to unit. The *CLS Course Student Self Study Manual* trains Soldiers to “attach the TCCC Card to the casualty or place the card in the upper left sleeve or the left trouser pocket of the casualty clothing.”¹⁶ In 2012, the Combat Casualty Care Course (C4) and TCMC courses trained Soldiers to tape the TCCC Card to the outside of the casualty’s hypothermia blanket.[†] The TCCC handbook does not indicate where the completed TCCC Card should be attached but does provide the alternative of using 3-inch white tape on the casualty’s chest and an indelible pen as an alternative to TCCC Card documentation.¹⁷ Additionally, in Afghanistan in 2014, it was noted that some units chose to annotate care information directly onto the casualty’s chest instead of using a TCCC Card.

By incorporating a standard location for attaching the TCCC Card to the casualty in the field, those who transport casualties or receive them at a treatment facility can anticipate and expect the TCCC Card. Thus, ensuring the card does not get discarded with clothing, blankets, and dressings. Based on C4 course training observations and discussions with members of the Committee on Tactical Combat Casualty Care and the Department of Combat Medic Training, the TCCC Card should be attached to the casualty’s wrist or the ankle.

CONCLUSION

In respect to DOTMLPF (Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities), and in contrast to those who believe that money and technology are the ultimate solutions to this problem, prehospital documentation and data capture is a Doctrine and Leadership issue. A mandate and policy for prehospital documentation and data capture, and the enforcement of this mandate through leadership, is required. Throughout most of the conflict in Afghanistan, the US military has collected minimal prehospital data. Updated prehospital documentation tools and a prehospital trauma registry is now in place; however, command ownership and leadership enforcement of this process is a requisite for achieving success. Leaders are accountable for the tactical combat casualty care given to their wounded Soldiers; consistent documentation of this care will permit performance improvement to thrive.

[†]Combat Casualty Care Course, March 2012, Camp Bullis, TX; Tactical Combat Medicine Course, July 2012, JBSA Ft Sam Houston TX.

REFERENCES

1. US Army Institute of Surgical Research. Joint Trauma System [internet]. Available at: http://www.usaisr.amedd.army.mil/10_jts.html. Updated March 16, 2015. Accessed September 8, 2015.
2. Sauer SW, Robinson JB, Smith MP, et al. Saving lives on the battlefield (part II)—one year later a Joint Theater Trauma System and Joint Trauma System review of prehospital trauma care in Combined Joint Operations Area—Afghanistan (CJOA-A) Final Report, 30 May 2014. *J Spec Oper Med*. 2015;15(2):25-41.
3. Kotwal RS, Howard JT, Orman JA, et al. The effect of a golden hour policy on morbidity and mortality of combat casualties. *JAMA Surg*; 2016;151(1):15-24.
4. Mabry RL, Apodaca A, Penrod J, Orman JA, Gerhardt RT, Dorlac WC. Impact of critical care-trained flight paramedics on casualty survival during helicopter evacuation in the current war in Afghanistan. *J Trauma Acute Care Surg*. 2012;73(2 suppl 1):S32-S37.
5. Nohrenberg JL, Tarpey BW, Kotwal RS. Data informs operational decisions: the tactical evacuation project. *United States Army Aviation Digest*. October-December 2014:17-19. Available at: http://www.rucker.army.mil/aviationdigest/images/Oct-Dec_100114.pdf. Accessed January 29, 2016.
6. Eastridge BJ, Mabry RL, Seguin P, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. *J Trauma Acute Care Surg*. 2012; 73(6 suppl 5):S431-S437.
7. Eastridge BJ, Mabry RL, Blackbourne LH, Butler FK. We don’t know what we don’t know: prehospital data in combat casualty care. *US Army Med Dep J*. April-June 2011:11-14.
8. Kotwal RS, Butler FK, Edgar EP, Shackelford SA, Bennett DR, Bailey JA. Saving lives on the battlefield: a Joint Trauma System review of pre-hospital trauma care in Combined Joint Operating Area—Afghanistan (CJOA—A) executive summary. *J Spec Oper Med*. 2013;13(1):77-85.
9. Kotwal RS, Montgomery HR, Mechler KK. A prehospital trauma registry for tactical combat casualty care. *US Army Med Dep J*. April-June 2011:15-17.
10. Kotwal RS, Montgomery HR, Kotwal BM, et al. Eliminating preventable death on the battlefield. *Arch Surg*. 2011;146(2):1350-1358.

PROGRAMMATIC IMPLEMENTATIONS TO IMPROVE HEALTH

11. Kotwal RS, Butler FK, Montgomery HR, et al. The Tactical Combat Casualty Care Casualty Card: TCCC Guidelines Proposed - Change 1301. *J Spec Oper Med.* 2013;13(2):82-87.
12. Geracci JJ, Kotwal RS, Day CD, Bailey JA, Costello CN. Implementation of a Joint Trauma System Pre-hospital Trauma Registry in Afghanistan: Cracking the Code on Data Capture for Tactical Combat Casualty Care. Oral presentation at the Special Operations Medical Association Scientific Assembly; Tampa, Florida; December 2013; and the Military Health System Research Symposium; Fort Lauderdale, Florida; August 2014.
13. Butler FK, Kotwal RS, Buckenmaier CC 3rd, et al. A triple-option analgesia plan for tactical combat casualty care: TCCC guidelines change 13-04. *J Spec Oper Med.* 2014;14:13-25.
14. Marcozzi D, Smith MP, Witte SM, Burrell E, Curtis RA, Gross KR. A 2013-2014 comparison of the potential benefit versus actual use of junctional tourniquets in a theater of operations. Poster presented at : The Special Operations Medical Association Scientific Assembly; Tampa, Florida; December 2014.
15. McGarry AB, Mott JC, Kotwal RS. A study of pre-hospital medical documentation by military medical providers during precombat training. *J Spec Oper Med.* 2015;15:79-84.
16. US Army. *Combat Lifesaver Course: Student Self Study Manual, Subcourse ISO0871.* ed C. Ft Sam Houston, TX: US Army Medical Department Center & School; September 2013:7-18.
17. US Army. *Tactical Combat Casualty Care Handbook.* Ft Leavenworth, KS: Center for Army Lessons Learned; March 2012 No. 10-44:18. Available at: http://www.globalsecurity.org/military/library/report/call/call_12-10.pdf. Accessed January 29, 2016.

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Abstract: Lessons Learned, Saving Lives on the Battlefield

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This abstract summarizes information presented to the Defense Health Board–Federal Committee to the Secretary of Defense, August 11, 2014, in Falls Church, Virginia, and later published in the *Journal of Special Operations Medicine*: Sauer SW, Robinson JB, Smith MP, Gross KR, Kotwal RS, Mabry RL, Butler FK, Stockinger ZT, Bailey JA, Mavity ME, Gillies DA 2nd. Saving Lives on the Battlefield (Part II) One Year Later A Joint Theater Trauma System and Joint Trauma System Review of Prehospital Trauma Care in Combined Joint Operations Area Afghanistan (CJOA-A) Final Report, 30 May 2014. *J Spec Oper Med*. 2015;15(2):25-41.

Based on peer-reviewed literature, up to 25% of deaths on the battlefield were potentially preventable and most preventable deaths occurred in the prehospital environment. Further advances toward significant improvements in combat trauma survival must occur at the point of wounding and during tactical operations. Strict adherence to the evidence-based Tactical Combat Casualty Care (TCCC) guidelines are proven to reduce morbidity and mortality on the battlefield, but full implementation across the entire force has been variable. Commitment to full implementation from both line and medical leadership continues to face ongoing DOTMLPF* challenges. This condition of variability has been described as “islands of excellence in a sea of mediocrity.” Two formal prehospital trauma care delivery assessments were conducted in Combined Joint Operations Area–Afghanistan (CJOA-A) by the US Central Command Joint Theater Trauma System (JTTS). The first occurred in November 2012 followed by the second from December 2013 thru January 2014. During the second assessment, the JTTS Prehospital Division directly interviewed deployed prehospital providers, medical leaders, and combatant leaders at 26 deployed locations while physically examining the available equipment and discussing the reviewed unit’s techniques, tactics, and procedures related to TCCC. It was notable that significant progress had occurred between the 2 assessments with the establishment of a Prehospital Care Division within the JTTS, development of a prehospital trauma registry, weekly prehospital trauma conferences, and CJOA-A theater guidance and enforcement of prehospital documentation. Specific national level prehospital trauma care achievements include expansion of transfusion capabilities forward to the point of injury, junctional tourniquets, and universal approval of tranexamic acid. However, without the enforcement of centralized doctrinal and policy endorsements, the military services and their subordinate prehospital trauma care delivery organizations continued to struggle to adequately and fully organize, train, and equip their forces

*Doctrine, organization, training, materiel, leadership & education, personnel, facilities

to meet TCCC guidelines. Among other issues, this variability in capability and implementation as evidenced in a lack of adoption of the TCCC’s recommended triple option analgesia, contraindicated medical material for traumatic eye care, and a lack of universal compliance with US Forces Fragmentary Orders concerning TCCC care delivery. Additionally, 27% of licensed prehospital care delivery medical leaders had not completed the Combat Casualty Care Course or training such as the Tactical Combat Medical Care Course. Finally, 12% of the supervising licensed healthcare medical leaders stated that there were TCCC recommended skills that they would neither train nor allow their enlisted medical personnel to provide. Among conventional US forces in the entire CJOA-A, only a single Role I had fully implemented the TCCC guidelines with all the necessary materials and scope of practice. These findings existed despite a standing memorandum and recommendations by the Assistant Secretary of Defense for Health supporting the incorporation of the published TCCC guidelines into both training and practice. In contrast, US Special Operations Command and US Army Special Operations Command have codified TCCC compliance as policy and reduced prehospital case-fatality rates. Also noted across multiple medical leadership levels were partial rejection or nonconcurrence and nonsupport of the TCCC guidelines. The evaluating team’s interactions with these leaders indicated the presence of a culture driven by hospital-based experiences and decision-making affected the capability of combat health care delivery at the organizational and unit level. Without understanding the unique nature of prehospital combat realities, this culture is unsuitable for ensuring a highly reliable delivery of field and combat medical care to our wounded. The team believed that this culture directly led the both the intentional and unintentional degradation of trauma care delivery in the theater among conventional forces:

1. The lack of standardized TCCC capability may represent a causal factor for the increased number of service members killed in action and of preventable

- deaths, and the increased case-fatality rate seen in conventional forces when compared with Special Operations Forces.
2. Absent a validated joint requirement which is captured doctrinally, the prevailing resource-constrained environment will challenge military services to fully organize, train, and equip to TCCC standards.
 3. There is no evidence that the DoD or CJOA-A has policies or procedures in place to validate or enforce prehospital care within an organization. Service-specific doctrine requiring unit surgeons to each establish a standard of care allows for variant, non-standard delivery of battlefield trauma care across the force. Furthermore, even within a single command, rotation of unit surgeons introduces and magnifies discontinuity of unit trauma-care standards.
 4. The requirements to perform and support prehospital TCCC could be standardized across the military services (universally or at the combatant command level) with the specific means to achieve these train-and-equip standards left up to the respective services.
 5. As with elements of prehospital care, organization structures are highly variant, with a number of at-risk forces not having adequately manned/trained/equipped medical support.
 6. Units with a tactical evacuation mission requirement should be task organized to be able to provide advanced en route resuscitative care from the point of injury.
 7. Robust training platforms exist for prehospital trauma care, though not all course syllabi keep pace with current best practices. Sufficient information technologies exist to rapidly and widely disperse new TCCC guidelines as they become immediately available.
 8. Unit equipment sets and supporting medical logistics systems have not kept pace with evolving prehospital care TCCC guidelines. Outdated items remain within the supply chain and newly required items have not yet been incorporated into standard configurations.
 9. In the absence of a widely mandated policy that establishes TCCC guidelines as the standard for prehospital battlefield care and accountability for deviations from this standard, the degree of penetrance and acceptance of TCCC guidelines will remain episodic and dependent upon individual (surgeon and commander) commitment.
 10. Neither line nor operational medical leaders are optimally prepared to recognize the importance of a robust prehospital care system or equipped with the requisite knowledge, skills, or experience to build or sustain such a system within their unit.

We must continue to embrace and explore emerging capabilities to deliver far-forward resuscitative care. History teaches that the lessons we have learned regarding combat casualty care may be lost if we fail to attend to them in the coming years. Even in a resource-constrained future, the Military Health System has the necessary personnel, organization, and experience to retain and refine our current best practices. With continued efforts aimed at (1) formalizing TCCC Guideline compliance across the force, (2) embracing evidence-based methods to continually improve upon these guidelines, and (3) selecting, developing, and retaining operational medical personnel dedicated to prehospital trauma care, the Military Health System will ensure an organizational culture that fully embraces prehospital combat casualty care as a core competency. We have a moral obligation to ensure that the advertised and expected capability is present at the point of injury for our service members.

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Traumatic Brain Injury Clinical Recommendations: Impact on Care and Lessons Learned

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ABSTRACT

Over 330,000 service members have been diagnosed with traumatic brain injury (TBI) since 2000. The Defense and Veterans Brain Injury Center (DVBIC) is uniquely positioned to identify knowledge gaps and disseminate information related to TBI to assist service members, clinical providers, and military families. The DVBIC utilizes a standardized process based on Institutes of Medicine and World Health Organization recommendations for the development of evidenced-based clinical guidelines. This presentation provided an overview of the need and process for developing TBI-specific clinical recommendations (CRs) related to diagnosis and treatment issues, and the lessons learned throughout their development. The development of CRs provides evidence-based, standardized guidance for symptom management and treatment recommendations following TBI. Included within the DVBIC process are site-specific adjustments that address the needs and requirements of our military stakeholders, including the operational challenges of the deployed setting. The identification of the need for TBI diagnosis and treatment guidelines within the Military Health System and the consideration of military service-specific and Department of Defense policy are integrated within an evidenced-based, systematic CR development process.

More than 330,000 service members serving on active duty during Operations Iraqi Freedom (OIF), Enduring Freedom (OEF), and Noble Endeavor (OND) have experienced a traumatic brain injury (TBI) since 2000.¹ When the conflicts in Iraq and Afghanistan began, the military medical community did not fully recognize the effect that improved body armor and combat vehicle modifications would have on traumatic brain injury—these advances in military armor decreased the incidence of moderate and severe TBI in comparison to previous military conflicts. The majority of TBIs in the US military are classified as mild (82.4%) and the remaining 17.6% categorized as moderate (8.5%), severe (1.0%), penetrating (1.5%), or other (6.6%).¹ The early recognition of TBI ensures that prompt treatment is initiated and maximizes the chances for a full recovery.² Military and Veterans Affairs medical practitioners rely on published guidance by the civilian medical community to aid them in the diagnosis, treatment, and return to activity decisions following TBI. It is imperative to understand how the military medical community translates the strongest medical and scientific evidence, expert opinion, and military experience (including combat) into timely and usable clinical tools to enable providers to offer the best care for TBI.

The Defense and Veterans Head Injury Program, later renamed Defense and Veterans Brain Injury Center (DVBIC), was established by Congress in 1992 to enable

research, treatment, training, and rehabilitative services for care of head injury as the Department of Defense (DoD) TBI Center of Excellence. Congressional mandates for care and reporting of concussion required setting a standard of care for the deployed setting that was evidence-based with special consideration of operational requirements and capabilities. Since 2012, DVBIC has served as the TBI operational component of the Defense Centers of Excellence (DCoE) for Psychological Health and Traumatic Brain Injury. In 2006, the DoD recognized the need for systematic guidelines for screening, diagnosis, and symptom management following acute concussion (Concussion Management in Deployed Setting/Concussion Management Algorithm (CMA)).³ The congressional mandate for care and reporting of concussion required setting a standard of care that was evidence-based for the deployed setting with special consideration of operational requirements and capabilities. This included the development and implementation of the Military Acute Concussion Evaluation (MACE)⁴ and the In-Theater Clinical Practice Guidelines.⁵ Medical surveillance data from DoD as well as existing medical literature identified mild TBI/concussion as having increased incidence with several associated symptoms requiring improved monitoring and management. Feedback from in-theater medical providers indicated that the previous version of the CMA was too complex, too difficult to read, and was not being widely implemented. Additionally, at that time, guidance for management of

concussion was only available for the subacute phase (less than 7 days) in the VA/DoD Clinical Practice Guidelines.⁶ As a result, developing and updating clinical recommendations (CRs) based on these identified needs from the field became a priority for DVBIC. The issuance of Directive-Type Memorandum (DTM) 09-033⁷ in June 2010 by the Deputy Secretary of Defense and later *DoD Instruction 6490.11*⁸ (which replaced DTM 09-033) in September 2012 directed mandatory processes for identifying those service members involved in potentially concussive events (ie, exposed to blast, vehicle collision, witnessed loss of consciousness, or other head trauma) to be screened for TBI. These new requirements for deploying units marked a significant transition from symptom-driven reporting to incident-driven reporting of suspected TBI. Incident-driven screening clarified for unit leadership and medical personnel all those personnel needing formal concussion screening. The desired result of this DoD guidance is the mitigation of the effects of potential concussive events on service member health, readiness, and ongoing operations, directly in keeping with a fundamental principle of patient care: early identification leads to early diagnosis, early treatment, and the best possible outcomes.

As the TBI operational component of DCoE and DoD's TBI CoE, DVBIC optimizes clinical care by combining evidence from medical literature, health care research, and expert opinion to develop and provide clinical guidelines to help military and VA healthcare providers deliver evidence-based treatment and address the challenges associated with TBI. Clinical guidelines for the management of conditions such as TBI can be classified as clinical practice guidelines (CPGs) or CRs. The Institute of Medicine (IOM) defines CPGs as:

Statements that include recommendations intended to optimize patient care which are informed by a systematic review of evidence and an assessment of the benefits and harms of alternative care options.⁹

CPGs are trustworthy guidelines which are based on a systematic review of the evidence, are developed by a panel of multidisciplinary experts, provide a clear explanation of the logical relationships between alternative care options and health outcomes, and provide ratings of both the quality of evidence and the strength of the recommendations. In comparison, CRs are defined as a systematically developed clinical guidance that provides evidence-based recommendations, including consensus, to guide the practitioner in the identification and treatment of specified clinical diagnoses, process,

or procedure.* Clinical recommendations are developed to fill an identified gap in knowledge or to provide clinical guidance for diagnosis, treatment, and evaluation of medical conditions. They promote evidence-based practice and standardized care, and they provide a mechanism for rapid translation of knowledge into clinical practice in the form of timely and practical clinical recommendations, a critical need for practitioners and leaders throughout the Military Health System (MHS). Consistency in development of CRs has advanced DVBIC participation and value within the MHS and its community of practitioners.

The development process for CRs includes 4 initial main steps as defined by the IOM⁹ and the World Health Organization¹⁰: (1) identify and define a clinical problem, (2) develop systematic reviews, (3) assemble a working group to develop clinical recommendations through appraisal of evidence and incorporate expert opinion, patient preferences and characteristics, and (4) use the guidance to make better informed decisions to improve health outcomes. Gaps or needs are identified through various means including the military (stakeholders), Quad Services Working Group (WG), government reports (such as the IOM or RAND Corporation), and current research. Requests may also come from the armed services, gap analyses, RAND studies, DVBIC/DCoE as the managers of the TBI Pathway of Care, or established committees and task forces. The DVBIC Clinical Affairs Division, Clinical Practice and Clinical Recommendations Office conducts ongoing reviews of existing products within the VA Health System, DCoE, and DVBIC to determine need for a CR, conducts a business case analysis once a need is identified, and determines an appropriate course(s) of action(s). A CR working group is established and includes representation from all services (Army, Navy, Air Force, Marines) and key government agencies (DCoE, Deployment Health Clinical Center, Center for Telehealth and Technology, National Intrepid Center of Excellence, Force Health Protection & Readiness/DHA Health Care Operations, US Central Command, and the VA) as well as subject matter experts from the civilian nongovernment sector. Consultants from civilian academia and research as well as the military are invited to participate in CR working groups. These working groups are multidisciplinary and well balanced with representation from all populations expected to be affected by the guidelines.

The next step in the CR development process is the identification of an internal DVBIC project team; this

*Internal DoD documents not readily accessible by the general public:

Standard Operating Procedure. Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury
Standard Operating Procedure. Defense and Veterans Brain Injury Center

includes an action officer, co-action officer, DVVIC Clinical Affairs and Education Division representatives, VA liaison, and component center representatives as appropriate. The WG conducts systematic reviews and evidence synthesis related to the TBI-specific topic (eg, sleep management following mild TBI). A literature review is conducted as part of an ongoing process throughout the development stage. The DVVIC Research Division conducts a literature search using set terms applied to databases of nationally and internationally recognized organizations to obtain research-based support documents. Additional military-specific information is reviewed from surveillance data. Identification of key clinical questions is used to guide the development of the CR. The evidence is appraised and incorporated into expert opinion, patient preferences and characteristics toward answering the key clinical question(s) related to the CR topic. A meeting summary is produced that reflects the discussions and agreements within the group for clinical questions when there is a gap in the literature or weak evidence to support a recommendation. The Core WG develops specific guidelines into a draft CR narrative document. The outcomes of these expert discussions and agreements during the meeting are incorporated into the CR narrative paper. The draft CR includes 4 elements: (1) the CR narrative (a detailed description of the clinical need/question, evidence review, and recommendations), (2) a clinical support tool (typically a laminated card consisting of a management algorithm for the defined clinical question), (3) provider training slides, and (4) patient education information in the form of a patient fact sheet. An expert subject matter group and all military services review and provide comments on all 4 components of the CR. The recommended edits are adjudicated and incorporated into final CR. The draft documents are further vetted internally through all services prior to completion. The CR is reviewed against DoD and military service-specific policies before final release.

One of the most recently created CRs is titled “Progressive Return to Activity Following Acute Concussion/Mild TBI: Guidance for the Primary Care Manager in Deployed and Non-Deployed Settings.” This CR is novel and clinically effective because it represents the first step-wise approach for clinicians and patients to use to obtain maximal recovery using a supervised treatment regimen. This is an excellent example of how expertise gained by military occupational therapists, occupational therapy technologists, primary care physicians, and other specialists at the 11 concussion care centers in Afghanistan were integral to the CR-development process to provide an effective clinical tool. The success of this CR was recognized during development and a supplemental

(and related) CR for rehabilitation specialists was added to the CR portfolio. Additionally, these CRs are undergoing research studies to validate their effectiveness.

To date, DVVIC has released 11 CRs related to TBI as shown in Table 1. An overview of the CR content is presented in Table 2. All clinical recommendations can be downloaded or ordered as printed documents by accessing the DVVIC Educational Materials webpage: <https://dvvic.dcoe.mil/resources>.

The DVVIC process for the development of CRs is a dynamic methodology subject to recurring process improvement and has many challenges for an international, large organization as well as typical guideline implementation barriers. Beginning with the Sleep Management CR (released in 2014), pilot testing was conducted with primary care providers. In October 2014, DVVIC initiated a process improvement pilot as part of a larger effort by DCoE to assess and improve knowledge translation processes. The pilot was centered on the rapid knowledge translation into clinical practice of a timely and practical CR on sleep disturbances following mild TBI. The primary objective of the pilot was to assess the effectiveness of an educational program on the CR in terms of disseminating information to providers and subsequent implementation of the knowledge (ie, provider behavior change). Lessons learned from this initial pilot testing

Table 1. Defense and Veterans Brain Injury Center Clinical Recommendations for Traumatic Brain Injury.

Clinical Recommendation Title	Release Date
Military Acute Concussion Evaluation (MACE) and Clinical Management Algorithms	June 2006 Dec 2006
Cognitive Rehabilitation	Apr 2009
Driving Following TBI	Jul 2009
Indications and Conditions for In-Theater Post-Injury NCAT Testing	May 2011
Indications and Conditions for Neuroendocrine Dysfunction Screening Post mTBI	Mar 2012
Assessment and Management of Dizziness Associated with mTBI	Sep 2012
Assessment and Management of Visual Dysfunction Associated with mTBI (in collaboration with the Vision Center of Excellence)	Jan 2013
Neuroimaging Following Mild TBI in the Non-Deployed Setting	Jul 2013
Progressive Return to Activity Following Acute Concussion/mTBI: Guidance for the Primary Care Manager in Deployed & Non-deployed Settings	Jan 2014
Progressive Return to Activity Following Acute Concussion/mTBI: Guidance for the Rehabilitation Provider in Deployed & Non-deployed Settings	Jan 2014
Management of Sleep Disturbances Following Concussion/mTBI	Jun 2014

TBI indicates traumatic brain injury; NCAT, neurocognitive assessment tool; mTBI, mild traumatic brain injury.

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Table 2. Summary of the Defense and Veterans Brain Injury Center Clinical Recommendations.

<p>MACE: The Military Acute Concussion Evaluation is a concussion screening tool for the acute assessment of service members involved in a potentially concussive event. Available as pocket card & wallet card.</p>
<p>Cognitive Rehabilitation: This clinical recommendation addresses cognitive assessment and recommendations for interventions for persistent postconcussion cognitive symptoms. Outcome measures (program-based and patient-based) and core elements of cognitive rehabilitation program implementation are also addressed.</p>
<p>Driving Following TBI: The purpose of this consensus statement is to provide clinical recommendations to healthcare professionals within the Military Health System regarding the assessment of the ability to drive following traumatic brain injury, regardless of severity. It describes the TBI driving evaluation process to include recommendations for key elements for clinical providers to include in the comprehensive driving assessment following TBI.</p>
<p>Indications and Conditions for In-Theater Post-Injury Neurocognitive Assessment Tool (NCAT) Testing Clinical Recommendation: This clinical recommendation provides background of predeployment neurocognitive testing and the use of automated neuropsychological assessment metrics.</p>
<p>Neuroendocrine Dysfunction Screening Post Mild TBI Clinical Recommendation: This clinical suite serves as a reference tool offering medical guidance following indications from postinjury neuroendocrine screening.</p>
<p>Assessment and Management of Dizziness Associated with Mild TBI Clinical Recommendation: The Assessment and Management of Dizziness Associated with Mild TBI Clinical Recommendation and Reference Card provide primary care providers with an approach to evaluate dizziness following mild TBI and offers guidance on referral for further vestibular evaluation and care.</p>
<p>Assessment and Management of Visual Dysfunction Associated with Mild TBI: This clinical suite provides providers an approach to evaluate visual dysfunction following mild TBI and offers guidance regarding referral for further eye or visual evaluation and care.</p>
<p>Neuroimaging Following Mild TBI in the Non-Deployed Setting Clinical Recommendation: The Neuroimaging Following Mild TBI in the Non-Deployed Setting clinical recommendation and reference card offers guidance for a standard approach for imaging from the acute through chronic stages following mild TBI in the nondeployed setting.</p>
<p>Progressive Return to Activity Following Acute Concussion/Mild TBI: Guidance for the Primary Care Manager in Deployed and Non-Deployed Settings Clinical Recommendation: The Progressive Return to Activity clinical recommendation details the importance of aiding service members to progressively return to pre-injury activity and promotes the standardization of Military Health System care following a concussion. The recommendation can be downloaded individually or ordered as a part of the PRA suite for primary care managers.</p>
<p>Progressive Return to Activity Following Acute Concussion/Mild TBI: Guidance for the Rehabilitation Provider in Deployed and Non-Deployed Settings Clinical Suite: The Progressive Return to Activity clinical recommendation details the importance of aiding service members to progressively return to pre-injury activity and promotes the standardization of care following a concussion. The recommendation can be downloaded individually or ordered as a part of the PRA suite for rehabilitation providers.</p>
<p>Management of Sleep Disturbances Following Concussion/Mild TBI: Guidance for Primary Care Management in Deployed and Non-Deployed Settings: This clinical suite provides guidance regarding assessing and managing sleep disturbances associated with mild TBI and includes specific recommendations for helping service members and veterans in deployed and non-deployed settings manage symptoms of insomnia, circadian rhythm sleep-wake disorder and obstructive sleep apnea.</p>

focused on technology utilization, logistics, participants involved, content, and delivery of the training. Two of the most significant lessons learned were that pilot testing should be conducted on all future CRs developed within DVBIC, and that additional training delivery methods (eg, interactive/web-based training) should be explored. Overall conclusions from the Sleep CR pilot testing to be applied to additional CR development processes include evaluation and effectiveness research for the CR and the development an effective process of dissemination and implementation of CRs across the MHS.

CONCLUSION

Clinical recommendations, which provide a rapid translation of knowledge into clinical practice to fill an identified gap in knowledge or provide practical clinical guidance for diagnosis, treatment, and evaluation of medical conditions, are a critical need for practitioners and leaders throughout the MHS. Clinical recommendations also promote evidence-based practice and standardized care

through out the uniformed services medical community and its healthcare providers. The DVBIC has developed multiple CRs and TBI educational products over the past decade using a process that incorporates best practices and military medical requirements. Best practices for the development of evidence-based CRs and education information are well defined within DVBIC. The process, which includes the implementation and evaluation of CR and education products, is met with complex challenges when applied across an international clinical setting such as the MHS. The process, challenges, and outcomes of creating and disseminating CRs were reviewed in this article.

REFERENCES

1. DoD Worldwide Numbers for TBI. Defense and Veterans Brain Injury Center Website. 2015. Available at: http://dvbic.dcoe.mil/sites/default/files/DoD-TBI-Worldwide-Totals_2000-2015Q1-Q2-Aug18-2015.pdf. Accessed March 2, 2016.

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2. Ponsford J, Willmott C, Rothwell A, Cameron P, Kelly AM, Nelms R, Curran C. Impact of early intervention on outcome following mild head injury in adults. *J Neurol Neurosurg Psychiatry*. 2002;73:330-332.
3. Combat Medic/Corpsman Algorithm, Ver 4.0. Defense and Veterans Brain Injury Center Website. 2012. Available at: http://www.dcoe.mil/Content/Navigation/Documents/DCoE_Concussion_Management_Algorithm_Cards.pdf. Accessed March 2, 2016.
4. MACE-Military Acute Concussion Evaluation. Defense and Veterans Brain Injury Center Website. 2012. Available at: https://dvbic.dcoe.mil/sites/default/files/DVBIC_Military-Acute-Concussion-Evaluation_Pocket-Card_Feb2012.pdf. Accessed March 2, 2016.
5. Defense and Veterans Brain Injury Center Working Group on the Acute Management of Mild Traumatic Brain Injury in Military Operational Settings. Clinical Practice Guideline and Recommendations. Deployment Health Clinical Center Website. 2006. Available at: http://www.pdhealth.mil/downloads/clinical_practice_guideline_recommendations.pdf. Accessed March 2, 2016.
6. VA/DoD Clinical Practice Guidelines: Management of Concussion/Mild Traumatic Brain Injury. US Department of Veterans Affairs Website. 2009. Available at: <http://www.healthquality.va.gov/guidelines/Rehab/mtbi/>. Accessed March 2, 2016.
7. Deputy Secretary of Defense. Directive-Type Memorandum (DTM) 09-033, "Policy Guidance for Management of Concussion/Mild Traumatic Brain Injury in the Deployed Setting." Washington, DC: US Dept of Defense. June 21, 2010. Available at: <http://www.govexec.com/pdfs/062510bb1.pdf>. Accessed March 2, 2016.
8. *Department of Defense Instruction 6490.11: DoD Policy Guidance for Management of Mild Traumatic Brain Injury/Concussion in the Deployed Setting*. Washington, DC: US Dept of Defense; 2012. Available at: <http://www.dtic.mil/whs/directives/corres/pdf/649011p.pdf>. Accessed March 2, 2016.
9. Institute of Medicine. *Clinical Practice Guidelines We Can Trust*. Washington, DC: National Academies Press; 2011. Available at: <http://iom.nationalacademies.org/Reports/2011/Clinical-Practice-Guidelines-We-Can-Trust.aspx>. Accessed March 2, 2016.
10. World Health Organization Handbook for Guideline Development, 2nd ed. Geneva, Switzerland; World Health Organization; 2014. Available at: http://www.who.int/entity/kms/handbook_2nd_ed.pdf?ua=1. Accessed March 2, 2016.

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MILITARY QUANTITATIVE PHYSIOLOGY:
PROBLEMS AND CONCEPTS IN MILITARY OPERATIONAL MEDICINE

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Acute and Chronic Pain on the Battlefield: Lessons Learned from Point of Injury to the United States

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ABSTRACT

Historically, war tends to accelerate innovation within military medicine. In this article, the authors argue this truism has recurred in the case of acute and chronic pain management for combatants in the global war on terrorism (GWOT). Advances in regional anesthesia techniques and multimodal acute pain care are highlighted in light of the typical weapons, injuries, and comorbid conditions of the modern combat era. Reported success of providing chronic pain care in the war theater during GWOT is discussed in the context of operational requirements for current and future wars. A description is provided of the Pain Management Task Force (PMTF) and Pain Campaign Plan which was initiated during GWOT. The PMTF effort enhanced pain education and clinical pain care through leadership and organizational changes, which created broader access to pain treatments for patients and more standardized treatment capabilities across the enterprise.

Inadequately treated trauma pain in combat unleashes a cascade of adverse physiological and psychological insults.¹ Numerous medical advancements occurred within the international medical community that were independent from but concurrent with the global war on terrorism (GWOT). Many of these exciting developments in medicine such as ultrasound-guided regional anesthesia and advanced regional anesthesia were leveraged within combat casualty care early in GWOT to improve Soldiers' battlefield pain control and potentially reduce chronic pain in wounded veterans.

Several pharmacologic, nonpharmacologic, technologic, and strategic advances which significantly reduced acute pain on the battlefield emerged and were successfully fielded during GWOT.^{2,3} Immediate and sustained air superiority enabled continued adherence to previously learned lessons from Vietnam and Desert Storm such as rapid evacuation of the combat wounded. Rapid evacuation in concert with early multimodal pain management has significantly improved combat casualty care from the point of injury through rehabilitation efforts months and years following combat injury. One commonly advanced narrative suggests that Soldiers injured early in GWOT received Civil War era analgesia (morphine monotherapy).^{1,4,5} The alternative view counters with eyewitness accounts of wartime anesthetics performed as early as April 2003 when powerful synthetic opioids, sedatives, and regional anesthetics (axillary nerve blocks) were used near the front lines to provide multimodal analgesia in a combat support hospital on the outskirts of Baghdad, Iraq. Further buoying these assertions

are reports from the 1960s when Army Anesthesiologist CPT Gale Thompson pioneered and published the repeated use of axillary regional anesthetics for battlefield pain control during the Vietnam War.⁶ While acknowledging the limitations of morphine monotherapy and an overreliance on opioids, the authors recognize that morphine has for centuries proved to be an excellent analgesic for acute trauma victims. Recently, morphine was lauded by Holbrook and colleagues in their observational study⁷ which suggested the use of morphine in US military personnel during combat-related trauma may reduce the risk of subsequent development of PTSD after serious injury. Considering approximately 17% of all returning Soldiers in GWOT experience PTSD and an even higher prevalence exists among injured Soldiers, acute pain control with morphine or other multimodal regimens will clearly have a positive effect on GWOT Soldiers' long-term health.⁸

One of the greatest advances in pain control during GWOT was the introduction and management of advanced regional anesthetic techniques, specifically, continuous peripheral nerve block (CPNB) catheters and infusions. In light of the enemy's continual use of improvised explosive devices and the subsequent tsunami of traumatic extremity amputations that ensued, CPNBs proved vital for acute and chronic battlefield pain control throughout the entire medical evacuation chain. COL Jack Chiles, a forward-thinking Anesthesiology Consultant to The Army Surgeon General, prioritized education and training by sending Army anesthesiologists MAJ Trip Buckenmaier and MAJ Scott Croll

to Duke University in 2001 and 2003 respectively to perfect these novel techniques. Completion of this training set in motion a cascade of educational and strategic advances for current and future US Army anesthesiology trainees and propelled advanced regional anesthesia to the forefront of the battlefield beginning in October 2003 with the first combat CPNB.⁹ In 2004, Walter Reed Army Medical Center (WRAMC) established the sole Department of Defense (DoD) fellowship in Acute Pain Medicine. Immediately, WRAMC anesthesiology residents and fellows rocketed into the 99th percentile nationally in advanced regional anesthetic techniques, which included CPNBs and the use of multimodal analgesia.

Significant improvement has been achieved in the combat trauma-related perioperative use of multimodal analgesia, yet significant obstacles still exist to achieving high quality, consistent use of intravenous adjuncts such as ketamine, propofol, benzodiazepines, clonidine, ketorolac and acetaminophen between Roles 2 and 5. Progress is often flush with unforeseen challenges and barriers to success, and the implementation of multimodal analgesia is a case in point. Even the infusion pumps used to administer such medications (patient-controlled analgesia and CPNBs) along the air evacuation system required official USAF certificates of airworthiness, which took considerable effort and time to obtain. A lack of familiarity with some of these medications or techniques led to significant resistance to implementation but was eventually overcome with education, training and persistence.

The relationship between the battlefield and chronic pain remains a complex one. It is difficult to predict which patients will develop chronic pain from an acute injury in the war zone and even more difficult to predict how such pain will affect the overall quality of life of such a casualty. The biopsychosocial (BPS) model emphasizes the role mental health and social milieu play in the overall experience of diseases, including chronic pain.¹⁰ Evidence from the wars in Iraq and Afghanistan support the application of such a model to pain on the modern battlefield. Some Soldiers injured in battle do not develop chronic pain even when significant injuries intuitively suggest they would. Many who develop chronic pain are able to manage it well enough to preserve a high quality of life. Epstein's 2010 study of quality of life for amputees from both Vietnam and GWOT illustrates the importance of psychosocial factors. He showed that patients with multiple amputations had a higher quality of life, while factors such as depression and poor prosthesis satisfaction predicted lower quality of life.¹¹ On the other hand, nonbattle musculoskeletal injuries, similar

to those seen in military training and civilian vocational settings, are a leading cause of evacuations from the war zone, with such Soldiers rarely returning to the battlefield.¹² Each circumstance emphasizes the importance of the psychosocial milieu through which a pain event is experienced.

Some meaningful outcome and risk factor data has emerged regarding the prevalence of chronic pain, opioid therapy, patient risk factors, and comorbidities. Toblin showed Soldiers develop more chronic pain than a similar civilian population when he studied 2,876 of 3,076 Soldiers from a brigade combat team (BCT) returning from the war. Forty-four percent of the BCT participants reported chronic pain versus 26% from a civilian population he studied prior.^{13,14} Almost 3 times as many from the BCT population were treated with opioids. Certain risk factors for chronic pain were noted, including female sex, aged 30 years or more, a history of current or prior marriage, lower rank, higher combat intensity, and combat injury.¹⁴ Seal found that veterans are at greater risk for complications of opioid therapy but are more likely to be treated with opioids than civilian counterparts.¹⁵ These and similar studies suggest that while opioid concerns in the military have been a reflection of trends in the civilian population, the efforts of military leaders to limit opioids where appropriate and develop integrative pain treatment approaches are grounded in science and a practical need to preserve a fighting force that is at higher risk for complications of opioid therapy.

A full understanding of the patient factors and treatment paradigms that affect the conversion of acute to chronic pain for a significant subset of Soldiers with either battle or nonbattle injuries has not emerged. What is clear from existing literature is that poorly managed acute pain contributes to development of chronic pain such that a systematic approach to acute pain within the battlefield evacuation system should have a favorable effect.¹⁶⁻¹⁸ The subject rightfully remains a major focus of future research within the military and beyond. Just as with the evolution of acute pain management including advanced regional anesthetics and multimodal medication therapy, some useful advances have emerged in the treatment of chronic pain.^{9,19} Clinics to treat chronic pain in theater have emerged at times when personnel and time allowed, and the retrospectively published experiences of such clinics show encouraging results in terms of treatments allowing Soldiers to continue missions in theater.²⁰ Prospective studies could guide future doctrine and policy decisions in terms of deciding the personnel and capabilities that should be available in theater for chronic pain management in the future.

As we continue current combat efforts and consider future conflicts, improved management of Soldiers with common, nonbattle injuries such as musculoskeletal pain may be as important as casualty care in preserving combat power. An increasingly complex and technologically advanced battlefield has increased the need for Soldiers with specialized and, in some cases, unique training. Reserve forces have remained a key element of overall force structure supplying such expertise. Soldiers are older on average than in previous wars. As the Army continues to shrink and Soldiers become more specialized, the need for chronic pain services on the modern battlefield will take on added importance for the Army to succeed in keeping key leaders and personnel in the fight. Several news stories emerged during the mid to late 2000s documenting both abuse and diversion of opioids as well as instances of inadequate pain control in some wounded warriors. Organizations internal to the Army such as the Defense and Veterans Center for Integrative Pain Management likewise began to document the need to modernize and integrate pain management from point of injury to definitive care. By August 2009, then Army Surgeon General LTG Schoomaker chartered the Army Pain Management Task Force (PMTF) to

make recommendations for a MEDCOM [Army medical command] comprehensive pain management strategy that was holistic, multidisciplinary, and multimodal in its approach, utilized state of the art/science modalities and technologies, and provided optimal quality of life for Soldiers and other patients with acute and chronic pain.^{21(pE-1)}

The PMTF had broad representation from the DoD, Veterans Administration (VA), and civilian pain treatment communities and assessed the state of pain care at the time. LTG Schoomaker emphasized standardizing pain treatment capabilities without stifling innovation. In May 2010 his office published the final report from that effort.²¹ The report offered 109 recommendations in 4 areas:

1. Provide tools and infrastructure that support and encourage practice and research advancements in pain management.
2. Build a full spectrum of best practices for the continuum of acute and chronic pain, based on a foundation of best available evidence.
3. Focus on the warrior and Family-sustaining the force.
4. Synchronize a culture of pain awareness, education, and proactive intervention.

The PMTF results led to a Pain Campaign Plan that recognized the importance of primary care providers (PCPs) and their teams in pain management, noting the majority of patients receive their pain care from the physicians, physician assistants, and nurse practitioners working as primary care providers across the force. A stepped care model that existed within the VA was adopted and led to organization and leadership changes affecting both pain education and clinical care by adapting and evolving existing local, regional, and enterprise level clinical and command capabilities.²¹ Pain education was noted to be inadequate at most levels and televideo capabilities were leveraged to provide better support of the PCPs. In addition, Primary Care Champions were designated and given multimodal training including televideo, in-person training, and development of more comprehensive skills through courses such as medical acupuncture with associated certification. Finally, clinical leaders at newly identified regional interdisciplinary pain management centers transitioned to leading broader clinical teams including physical, occupational, and behavioral health specialists, integrative medicine physicians, exercise specialists, and chiropractors and acupuncturists who would rarely work so closely in traditional pain practices. Functional restoration programs have emerged and early outcomes support such efforts to treat Soldiers with chronic pain more comprehensively as the effort has led to encouraging return-to-duty rates.²²

Acute and chronic pain care within military medicine has evolved significantly as a result of the GWOT. Prioritizing pain education coupled with organizational and leadership emphasis have advanced treatment techniques and paradigms in both arenas. As the operational tempo of combat decreases and treatment of combat associated pain becomes less common, it is imperative that the knowledge and skills acquired be retained. With reasonable attention, regional anesthesia, multimodal analgesia, and management of chronic pain for service members in deployed settings and beyond will be here to stay. Yet much of the research to define the best pain treatments for war is yet to be accomplished. Policy updates to codify what has been learned cannot be neglected during periods of decreased operational tempo. We can little afford to repeat the current lessons learned given the research, education, and leadership challenges we need to further understand and master. For the next war has always come, and experience suggests it is usually sooner than expected.

REFERENCES

1. Joshi GP, Ogunnaike BO. Consequences of inadequate postoperative pain relief and chronic persistent postoperative pain. *Anesth Clin North America*. 2005;23(1):21-36.
2. Buckenmaier CC, Mahoney PF, senior eds. *Textbooks of Military Medicine: Combat Anesthesia: The First 24 Hours*. Fort Sam Houston, TX: Borden Institute; 2015:205-244.
3. Malchow RJ, Black IH. The evolution of pain management in the critically ill trauma patient: Emerging concepts from the global war on terrorism. *Crit Care Med*. 2008;36:S346-S357.
4. Buckenmaier CC, Bleckner L. *Military Advanced Regional Anesthesia and Analgesia Handbook*. Fort Sam Houston, TX: Borden Institute; 2008:1. Available at: <http://www.dvcipm.org/clinical-resources/dvcipm-maraa-book-project>. Accessed March 9, 2016.
5. Talan J. On the front lines: learning from Iraq, military physicians craft new strategies for managing chronic pain. *Neurology Now*. 2008;4:33-34.
6. Thompson GE. Anesthesia for battle casualties in Vietnam. *JAMA*. 1967;201:215-219.
7. Holbrook TL, Galarneau MR, Dye JL, et al. Morphine use after combat injury in Iraq and post-traumatic stress disorder. *N Engl J Med*. 2010;362:110-117.
8. Hoge CW, Casto CA, Messer SC, et al. Combat duty in Iraq and Afghanistan, mental health problems and barriers to care. *N Engl J Med*. 2004;351:13-22.
9. Buckenmaier III CC, McKnight GM, Winkley JV, et al. Continuous peripheral nerve block for battlefield anesthesia and evacuation. *Reg Anesth Pain Med*. 2005;30:202-205.
10. Engel GL. The need for a new medical model: a challenge for biomedicine. *Science*. 1977;196:129-136.
11. Epstein RA, Heinemann AW, McFarland LV. Quality of life for veterans and service members with major traumatic limb loss from Vietnam and OIF/OEF conflicts. *J Rehab Res Dev*. 2010;47:373-386.
12. Cohen SP, Griffith S, Larkin TM, Villena F, Larkin R. Presentation, diagnoses, mechanisms of injury, and treatment of soldiers injured in Operation Iraqi Freedom: An epidemiological study conducted at two military pain management centers. *Anesth Analg*. 2005;101:1098-1103.
13. Toblin RL, Mack KA, Perveen G, Paulozzi LJ. A population-based survey of chronic pain and its treatment with prescription drugs. *Pain*. 2011;152:1249-1255.
14. Toblin RL, Quartana PJ, Riviere LA, Walper KC, Hoge CW. Chronic pain and opioid use in US soldiers after combat deployment. *JAMA Intern Med*. 2014;174(8):1400-1401.
15. Seal KH, Shi Y, Cohen G, Cohen BE, Maguen S, Krebs EE, Neylan TC. Association of mental health disorders with prescription opioids and high-risk opioid use in US veterans of Iraq and Afghanistan. *JAMA*. 2012;307(9):940-947.
16. Apkarian AV, Baliki MN, Farmer MA. Predicting transition to chronic pain. *Curr Opin Neurol*. 2013;26:360-367.
17. Feizerfan A, Sheh G. Transition from acute to chronic pain. *Contin Educ Anaesth Crit Care Pain*. 2015;15(2):98-102.
18. May A. Chronic pain may change the structure of the brain. *Pain*. 2008;137:7-15.
19. Jennings PA, Cameron P, Bernard S, et al. Morphine and ketamine is superior to morphine alone for out-of-hospital trauma analgesia: a randomized controlled trial. *Ann Emerg Med*. 2012;59(6):497-503.
20. White RL, Cohen SP. Return-to-duty rates among coalition forces treated in a forward-deployed pain treatment center: a prospective observational study. *Anesthesiology*. 2007;107(6):1003-1008.
21. Pain Management Task Force. *Providing a Standardized DoD and VHA Vision and Approach to Pain Management to Optimize the Care for Warriors and Their Families. Final Report*. Washington, DC: Office of The Army Surgeon General; May 2010. Available at: http://www.regenesisbio.com/pdfs/journal/pain_management_task_force_report.pdf. Accessed March 9, 2016.
22. Tiede JM, Earwood ME, Teuton KA. Functional Restoration in Active Duty Service Members: Initial Outcomes in Pain, Function and Opioid Utilization. Poster presented at: 30th Annual Meeting of the American Academy of Pain Medicine; March 8, 2014; Phoenix, AZ. Abstract available at: <http://www.painmed.org/2014posters/abstract-202/>. Accessed March 9, 2016.

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Leveraging Trauma Lessons from War to Win in a Complex Global Environment

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ABSTRACT

The US military has made great strides in combat casualty care since 2001. As the Army concludes combat operations in Iraq and Afghanistan, it faces new operational challenges in trauma care. The military medical community must stay ahead of the curve through sustaining current investments in combat casualty care research. This article describes lessons learned at war from a Joint Trauma System perspective in order to place in context how we should proceed in order to provide optimal care for our Warfighters in the future.

This is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.

Sir Winston Churchill, November 1942

As the US Army winds down from a decade of conflict involving 2 major theaters of war, we are naturally inclined to emit a sigh of relief. As he did in November of 1942 after the victory at the Second Battle of El Alamein, the insightful Sir Winston Churchill would remind us that the enemy is not dead, the threat is still real, and we have only just begun.

Even as we close over a decade of conflict in Afghanistan, we are faced with the threat of ISIS in Iraq. In Eastern Europe, Russia has flexed its military power in Ukraine by annexing Crimea. In Asia, North Korea continues to be an unfriendly nuclear presence. In the eastern Mediterranean and Middle East, the conflict between Israel and Palestine continues without a clear end in sight. A civil war in Syria is ongoing with spillover into Jordan and Lebanon causing increased unrest. Iran continues to seek nuclear technology for military use. Al-Qaeda in the Arabian Peninsula has been strengthened by the instability in Yemen. In Africa, Al-Shabab continues to launch terror attacks from Somalia into surrounding countries. There is violence and political instability in Egypt and Libya. The Seleka in the Central African Republic has created violence and mass atrocities as the insurgency continues. The internal political struggle in South Sudan has left 10,000 people dead and more than a million displaced. In the Western Hemisphere, we remain on alert for terrorist attacks such as that in Paris in November 2015. There is drug-related violence in Mexico that spills over into the United States. Following a decade of conflict, the reality is far from what we would like to imagine as “the end.” This evidence demonstrates that the world is still dangerous and perhaps increasingly complex.

The *US Army Operating Concept 2020-2040*¹ charges the Army to be prepared to operate in these environments in order to “win in a complex world.” The overarching strategy for success involves a global reach, while maintaining a regional relevance. Our military objectives may not be geographic locations such as a capital city, but a group of dispersed operations that contribute to the same overarching objective. To “mass on the objective” may involve coordinated efforts with other instruments of national power such as informational, economic, and diplomatic. Our success as an Army may be measured as much by our finesse as by our military might.

Despite significant success and advancements in combat casualty care (CCC) over the last 14 years, including the achievement of the lowest case fatality rate in our history² as shown in Figure 1, our future success as an Army is not guaranteed by our past performance. Certainly our future success is informed and led by the momentum that has been gained since 2001, but now is not the time to rest in regards to CCC. As leaders within the Army Medical Department, we are compelled to leverage CCC knowledge and technology advancements to win in an increasingly complex global environment. This article reviews these CCC lessons with an eye towards providing optimal CCC for future complex operational environments.

CREATION OF THE JOINT TRAUMA SYSTEM

Most of the success in CCC over the past decade can in some way be linked to the establishment of the Joint Trauma System. From the earliest published literature reviews, we discovered that Soldiers were dying from potentially survivable hemorrhage from the extremities, junctional areas of the groin and axilla, and noncompressible torso hemorrhage.³ At the time, there was no readily apparent solution to junctional and torso hemorrhage aside from rapid evacuation to surgical care. But

early in the last series of combat deployments, we realized the value of tourniquets in preventing death from extremity hemorrhage, and we sought to procure, train, and field this device.

As Iraq became increasingly a hard fought counterinsurgency and stability operation, many deployed surgeons realized that injury severity was increasing. In a comparison of potentially survivable injuries from 2003 and 2004 with those in 2006, the Injury Severity Score increased from 27 to 37 over that period, most likely secondary to blast injuries. Furthermore, hemorrhage (extremity 33%, torso 49%, and junctional 21%) still accounted for 87% of potentially survivable deaths.⁴ Frustratingly, Warfighters continued to die from exsanguinating extremity hemorrhage. It was apparent that we had not successfully trained and fielded tourniquets. The recommendation to the operational commanders for tourniquet use and the implementation of this recommendation was slowed by a lack of a feedback mechanism to make this happen.

In 2004, a group of trauma surgeons with clinical foresight and operational experience set out to create a trauma system for war.⁵ We knew from the accumulated civilian trauma literature over the prior 20 to 30 years that trauma systems decrease mortality from trauma by 15% to 20%.⁶⁻¹⁰ Furthermore, they recognized that the US military needed a formal trauma system to effectively implement changes that would lead to optimal care for our wounded. Based on the public health model, all essential components for a trauma system of care were addressed in the system but adapted to “patient care” in the unique battlefield environment as illustrated in Figure 2. Currently, the US Military Health System (MHS) Joint Trauma System (JTS) seeks to solidify itself as the standing body for global delivery of the MHS trauma system through approval of its JTS manual as joint doctrine.¹¹ The following are key examples by system component of successful JTS efforts since its inception.

Information Systems and Research

The JTS, first and foremost, was and still is a data-driven organization. The purpose of the Information Systems and Research components are to collect and analyze data. Thus, research teams were sent to each of the theaters to collect data in real-time. Early in this effort, research teams focused primarily on collecting data from the major trauma hospitals (Role 3 facilities), but as the JTS matured later in the war, the research teams were

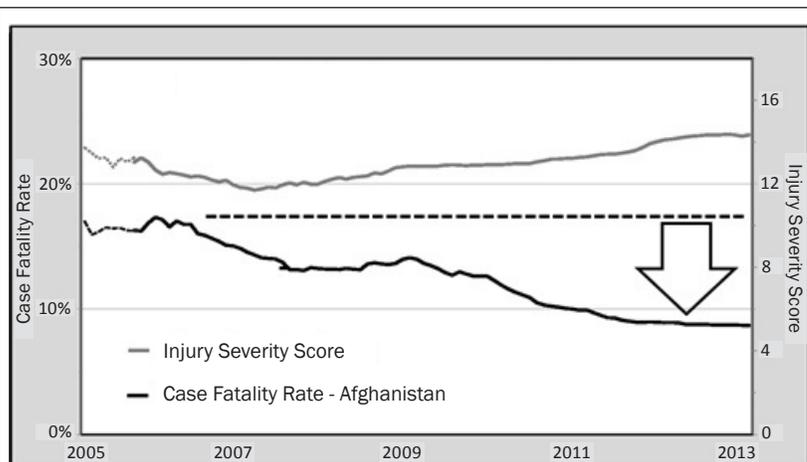


Figure 1. Case Fatality Rate (CFR) as compared to Injury Severity Score (ISS). The data demonstrates that as ISS was increasing between 2009 and 2013, the CFR was decreasing over the same time period. The data lends evidence to support the statement that military medical care decreased deaths in combat operations during that period. Source: Joint Trauma System. Reprinted with permission, CAPT Z. Stockinger, USN, Director.

able to reach out to many of the Role 2 surgical facilities as well. The Joint Theater Trauma Registry (JTTR, now renamed the Department of Defense Trauma Registry) was developed as the repository for this data. Shortly after data were collected, it was analyzed in order to identify gaps in care or processes that could be improved within the trauma system. This data was fed to research and development programs of the US Army Medical Research and Materiel Command (MRMC) such as the Combat Casualty Care Research Program (CCCRP). This program could then guide intramural and extramural trauma research sites to focus on aspects important to combat casualty care. Knowledge and material solutions to these gaps were then transferred to the user community through the JTS.

Prevention

The Prevention component used data from the JTTR to feedback to other programs at MRMC such as the Joint Trauma Analysis and Prevention of Injury in Combat program (www.jtapic.amedd.army.mil) for the improvement of body armor to protect the torso, pelvic, and groin regions, as well as improved eye protection. In coordination with multiple other groups, the development of mine-resistant and up-armored vehicles was also in part driven by data collected, analyzed, and presented through the work of the JTS.

Education

The Education component sought to improve the trauma care readiness of US military medical personnel deploying to both theaters of operation. The Joint Combat Trauma Management Course was developed to provide

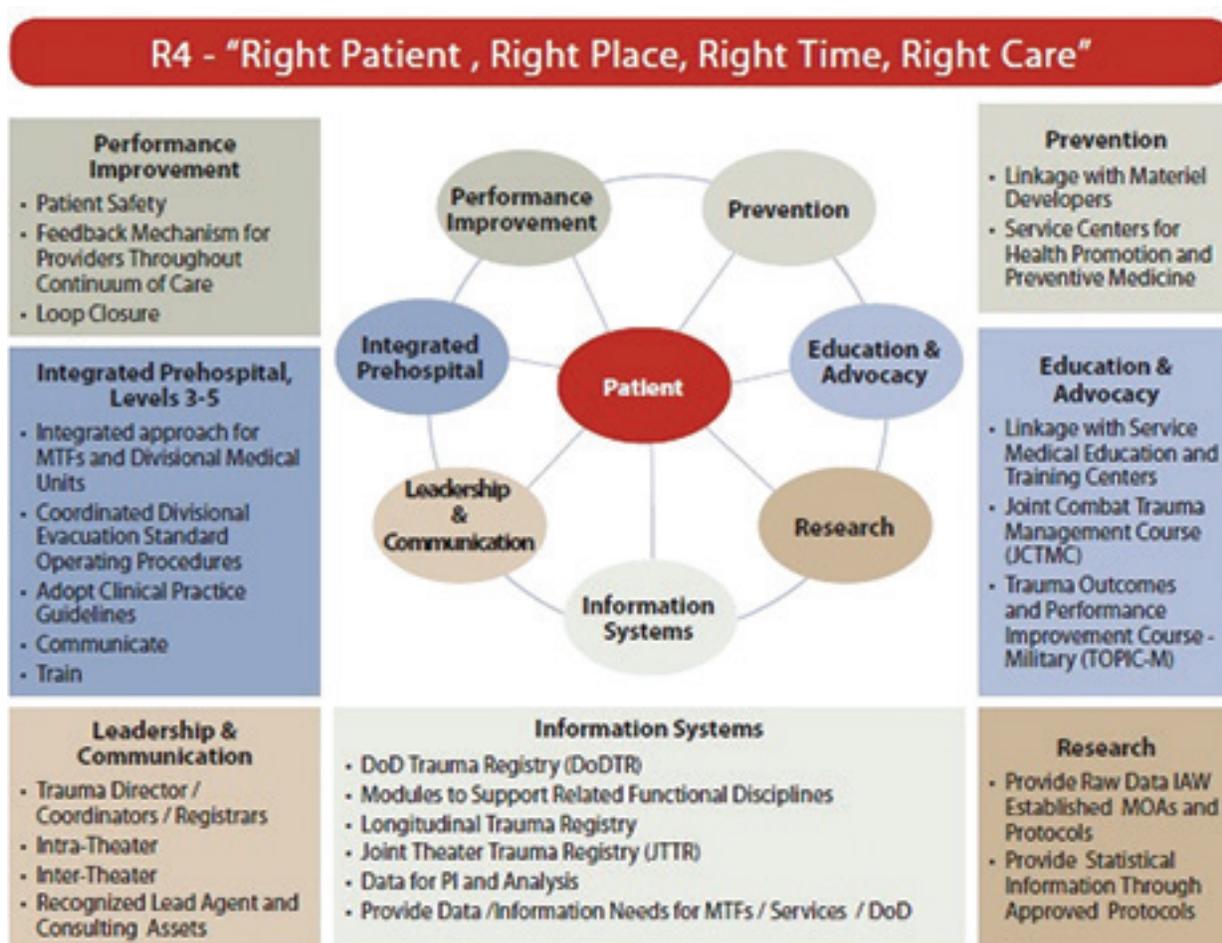


Figure 2. The Joint Trauma System. This schematic presents the components of a model trauma system that integrate and collaborate to make a system of care that is trauma patient-centric. Source: Joint Trauma System. Reprinted with permission, CAPT Z. Stockinger, USN, Director.

surgeons and others with “just-in-time” trauma refresher training prior to deployment. The services developed service-specific trauma training centers. For example, the Army developed the Army Trauma Training Center, first briefly in Houston and then in Miami, Florida, at the Ryder Trauma Center where it remains. This training center provided and still provides predeployment organization, skills, and knowledge training for Army Forward Surgical Teams. The Air Force also developed a program at the University of Maryland Shock Trauma Center in Baltimore, Maryland, and the Navy developed their trauma training center at the Los Angeles County–University of Southern California Medical Center. At the most fundamental levels, lessons from the JTS were transferred by individual returning surgeons to military surgical residents and to medical students of the joint Uniformed Services University School of Medicine. In this way, these lessons could not only serve the next round of deploying surgeons but could form the operational foundational experiences for potential future surgeons and trauma providers for all services.

From the early days, there were topics of trauma concern that called for effective clinical practice guidelines (CPG). Guidelines involving such issues as damage control resuscitation (DCR), use of fresh whole blood, treatment guidelines for burns, fasciotomy, and many other topics of clinical importance were created to guide the deployed surgical workforce. Concurrently, the JTS initiated weekly telephone conferences with all stakeholders of the JTS. This truly phenomenal weekly morbidity and mortality review spanned the entire continuum of care from the point of injury (POI), to the various locations within the 2 theaters, to Landstuhl Regional Medical Center, our regional Role 4 facility, to military hospitals in the United States such as Walter Reed Army Medical Center, Naval Hospital Bethesda, and Brook Army Medical Center, and finally to the Veteran’s Affairs (VA) rehabilitation centers. This all-inclusive, all-hands-on teleconference truly brought medical personnel working within a global continuum of care together as one trauma system of care. The resulting feedback to and from all points in the continuum of the trauma

system was of immense benefit in improving the care provided.

Leadership

As mentioned previously, direct access to operational leadership was a key factor in making the JTS an effective mechanism to improve outcomes within the US military. The Leadership component advocated for and deployed a Joint Theater Trauma Director who was responsible for the in-country research team in both theaters, and for compiling, analyzing, and presenting current data from the JTTR directly to the Commander, US Central Command on a monthly basis. This was the access needed to ensure that the JTS voice was heard and was effective in the implementation of important changes.

Prehospital Care

Prehospital Care, controlled by the medical evacuation commanders and physician-consultants known as flight surgeons, was integrated into the education portion of the JTS through its involvement in the weekly telephone conferences and the process of CPG creation. For example, when data showed that patients were becoming hypothermic during transport, operational leadership facilitated communication to the medical evacuation units regarding using hypothermia prevention kits and temperature “dots” on patient foreheads to monitor temperature during transport.

Performance Improvement

Performance Improvement was woven throughout the JTS components. As data was collected and analyzed, feedback was immediately provided to all elements of the JTS, to and from the medic at the POI to the flight medic on the helicopter, to the surgical teams and combat support hospitals, and onward out of theater. Any point along the continuum was empowered to provide constructive feedback to improve the JTS.

APPLYING THE JOINT TRAUMA SYSTEM TO A THEATER OF WAR

The JTS, with its components, was then overlaid onto the established Roles of Care within the theaters of Afghanistan and Iraq, as shown in the Table. Along with the components needed to create an effective trauma system, there was also a need for a geographically organized physical system of care. The NATO roles of care were already in place but were not an established part of an overarching system of care. As data was gathered, important and timely feedback was given to the medics and trauma teams working within the JTS at these roles of care. So although geographically dispersed in 2 theaters, the units working these roles of care were

still connected by the JTS. Shared lessons learned from one role of care in one theater often had applicability to trauma care provided at similar roles in the other theater. The JTS provided the medical leadership necessary to stay focused on providing care within each respective role within the overall trauma system. Furthermore, the JTS enabled CCCRP clinicians and scientists to assess data and feedback from the battlefield and translate this directly into material and knowledge products that improved CCC in near real time. It is important to understand the perspective of the Roles of Care on the battlefield to fully appreciate these improvements in care.

Role 1

At Role 1 (POI to battalion aid station), the Committee on Tactical Combat Casualty Care (CoTCCC) has advised the sequence of care for patients injured on the battlefield since the late 1990s. Providing hemorrhage control was the most critical life-saving intervention, even above the standard civilian teaching of “airway, breathing, and circulation” (ABC). Thus, initial external hemorrhage control prior to ABCs was institutionalized to save lives by stopping life threatening hemorrhage prior to any other medical concerns. To that end, tourniquets were fielded to deploying Warfighters within newly designed individual first aid kits (known as IFAKs) with the priority of extremity hemorrhage control. The concept of “hypotensive resuscitation,” providing intravenous (IV) fluids only when absolutely necessary in order to allow a clot to form and prevent too high of a blood pressure from dislodging the clot, was added to medic training. Based on CoTCCC guidelines, Army medics learned advanced techniques to open and maintain airways, such as surgical cricothyroidotomy. Another significant cause of death on the battlefield, tension pneumothorax from chest wounds, was likewise addressed in CoTCCC guidelines and medics were taught to relieve the pneumothorax using a long, large bore IV catheter. Providing analgesia for pain management and giving antibiotics at or near the POI were also concepts that were derived from this committee. The best solution for junctional or noncompressible hemorrhage was initially tightly packed dressings and then hemostatic dressings, until junctional tourniquets were recently made available to deployed medics.¹³

Medical Evacuation from POI

Flight medics were limited in scope of practice although additional resources could be carried onboard helicopters. Recommendations by CoTCCC for care during evacuation involved reevaluation of the patient with hemorrhage control remaining the highest priority, followed by an airway intervention only when absolutely necessary, and decompression of a tension

PROGRAMMATIC IMPLEMENTATIONS TO IMPROVE HEALTH

NATO Roles of Care. ^a		
Role of Care	Personnel	Details of Intervention
Role 1	“Buddy aid,” Medical technician/corpsman Flight medic Aid station physician or PA	Initial life-saving care rendered at and near point of injury Involves Tactical Combat Casualty Care: care under fire, tactical field care, care during evacuation
Role 2	General or emergency physician PA Nurse Medical support personnel	Basic resuscitation and stabilization for transport to surgical location or Role 3 Usually has basic x-ray, laboratory, blood capability, and small holding capability
Role 2-Surgical ^b	Surgeons for general and orthopedic trauma care OR, ER, ICU nurses Medical support personnel	Advanced resuscitation and stabilization and damage control surgery capability Trauma/ED, OR, and ICU sections Usually has blood capability and small holding capability May have basic x-ray and laboratory capability
Role 3	General and subspecialty surgeons ED, ICU, radiology physicians Specialty nurses Medical support personnel	Most robust trauma hospital in theater of operations, usually with neurosurgery, ENT, and ophthalmology support CT scanner with radiologist Full operating rooms and ICU care Full laboratory support Full blood bank
Role 4	Full hospital personnel	Outside theater of operations; a full trauma hospital that provides care from admission to rehabilitation.

^aDerived from NATO publication AJP-4.10(A)-Allied Joint Medical Support Doctrine.¹²
^bRole 2 - Surgical is a US military term for a Role 2 with surgical capability in distinction from a US military Role 2 without surgical capability. This differs from NATO doctrine which always defines Role 2 with surgical capability.^{12(p1-9)}

pneumothorax if detected. Intravenous fluids were given only to maintain patient consciousness in line with the hypotensive resuscitation training. Towards the end of the conflicts from 2012 to 2014, medical evacuation units began to carry blood in “golden hour” cooler boxes and to use tranexamic acid (TXA) to promote blood clotting in those likely to require massive transfusions. Furthermore, review of outcomes revealed that the severely injured benefited from paramedic trained flight medics, USAF Pararescuemen, and United Kingdom Military Emergency Response Teams (with critical care flight nurses, anesthesiologists and emergency physicians) when compared to basic, entry-level US flight medics.^{14,15}

Role 2-Surgical

At Role 2-Surgical facilities, we learned that damage control involved resuscitation for physiologic improvement alongside the surgery for anatomic control of bleeding and contamination. We learned to understand our role of care within the JTS, including the importance of personnel and equipment resources, postoperative critical care capacity, and medical evacuation availability remaining continuously ready for more casualties. We learned to maintain a situational awareness of the battlefield effects that might influence military surgical decision-making for each individual casualty and for multiple casualties. These included a knowledge of the ongoing operations in the area, types of weaponry used by the enemy (for example, blast versus high velocity

rifle), number of friendly and enemy troops engaged or at risk, etc. These mission and operational variables could affect our capacity and capability to function.

Surgeons at the Role 2-Surgical facilities used simple x-ray and portable ultrasound along with patient physiology to determine the need for immediate surgery and in which cavity or extremity it was needed. Surgeons shunted vascular injuries to maintain perfusion. They used temporary abdominal wound closures to rapidly get the patient out of the operating room (OR) and to the intensive care unit (ICU), rapidly clearing the OR table for the next patient. They gave packed red blood cells (PRBC) and fresh frozen plasma (FFP) to resuscitate severely injured patients per the Damage Control Resuscitation CPG when available. These teams also organized “walking blood banks” to collect fresh whole blood when components failed or were not available.

Intratheater Transfers

Flight medics were often required to transport complex, postoperative patients who had undergone damage control surgery (DCS). These patients were often intubated, ventilated, and sedated, with an ongoing need for resuscitation. This essentially was an interfacility ICU patient transfer which exceeded the training of the standard US Army flight medic. In 2009, we began to train Army Nurses at the Joint Enroute Care Course and then to deploy critical care flight nurses to perform this higher complexity, interfacility transport mission.

Role 3

At Role 3, DCR was more robust due to increased manpower, a larger blood supply, and the availability of platelets. In 2007, Borgman et al¹⁶ published their findings from deployment to an Army combat support hospital. They determined from their data that those severely injured patients receiving a high ratio of FFP:PRBC had a decreased overall mortality compared to the use of low ratios or no FFP at all (19% vs 65%, respectively). Mortality due to hemorrhage in this same high to low ratio resuscitation population was 37% vs 92%, respectively. This was followed by numerous civilian center blood product ratio studies, most of which showed decreased mortality from severe trauma with early and rapid transfusion of 1:1:1 ratio of blood, plasma, and platelets in those patients requiring a massive transfusion (more than 10 Units PRBC in the first 24 hours).¹⁷⁻²⁰ The Military Application of Tranexamic Acid in Trauma Emergency Resuscitation Study conducted at the United Kingdom Role 3 surgical hospital in Bastion, Afghanistan, showed that the use of TXA for patients requiring a massive transfusion decreased mortality to 14% from 28% in 896 retrospectively studied patients.²¹

In the combat support hospitals, the presence of neurosurgeons and a CT scanner allowed for rapid diagnosis and life-saving surgery for traumatic brain injury. Multiple other subspecialists were available as well, including vascular surgeons, ENT surgeons, plastic surgeons, and orthopedic surgeons to provide ongoing DCS with second look procedures, vascular reconstructions, and complex pelvic stabilizations.

A fully functional ICU staffed with a board certified intensivist facilitated management of complex multisystem critical care prior to evacuation from theater. Finally, development and implementation of the mobile Burn Resuscitation Decision Support System allowed for forward optimal burn resuscitation at the Role 3 theater hospitals.

As we saved more severely injured patients, we had to develop new techniques for limb salvage, flap reconstruction, restoration, prosthetics, and rehabilitation at VA rehabilitation centers and military medical centers in the United States.

Transport from Theater

The Air Force Critical Care Air-Transport Team revolutionized theater medical evacuation, expanding evacuation to a global scale. The most severely injured patients could now be transported to the United States within days of injury. Similarly, the Army Burn Transport Team transported burned, multisystem injured casualties to

the Burn Unit at San Antonio Military Medical Center. En route care capability included the care of complex critically injured patients requiring ventilation, medications to augment blood pressure, various tubes and drains, temporary abdominal and wound closure devices, and even extra-corporeal membrane oxygenation.

REQUIREMENTS-DRIVEN COMBAT CASUALTY CARE RESEARCH

We have made great strides in the past 14 years of prolonged conflict in 2 theaters of war. The Joint Trauma System was forged from necessity during war and its success is documented by the improvement in CCC as its initial legacy. However, our past success does not guarantee future performance. We must not drift back to the CCC of 2001, and we must not be naïve in thinking that we can now rest on our recent success. We must continue the momentum that took us so long to gather in order to stay ahead of the curve. As in a past generation, we must take heed of Winston Churchill's wisdom and press on with the knowledge that there are more challenges to be faced and overcome. Our goal should be to begin the next conflict better prepared than we are today.

The Combat Casualty Care Research Program is poised to set a heading for success. To succeed, we must answer the question, "How does the Military Health System, and specifically the US Army, win in a complex world?" The answer is to create simplified DCR interventions (DCRi) that can be applied to future operations.

Near Term (2-5 Years)

In the near term, this means we capitalize on our current science and technology investments by seeing products from current research through to completion and into the hands of the Warfighters. We seek technology to bring whole blood and freeze-dried plasma to the POI. We look to bring expandable foam technology for junctional and abdominal hemorrhage to the battlefield. We will implement novel advanced physiologic monitoring solutions for use in triage and resuscitation.

We will focus on new operational challenges to trauma care such as prolonged DCR scenarios, including prolonged field care, delayed evacuation, prolonged evacuation, remote operations, or challenging megacities. Prolonged DCR solutions must include new technology for blood resuscitation, advanced physiologic monitoring, and control of junctional and torso hemorrhage. In the near future, we hope to deliver critical medical supplies to remote locations with unmanned aircraft.

At Role 2 DCS teams, we aim to become lighter and more versatile by leveraging totally intravenous anesthesia,

next generation vascular shunts, and integrated, closed loop patient physiology monitors that translate data throughout the continuum of care. We envision air-based surgical teams and simplified surgical interventions that can be brought forward to the patient. At the Role 3, we will see the use of endovascular balloon hemorrhage control devices and portable extracorporeal life support for lung, renal, and potentially cardiac support.

Mid- to Long-Term (5-10 Years and Beyond)

At the same time, we must seek the next generation of “leap-forward” type science and technology that will allow us to create knowledge and material products for Future Forces 2025 and beyond. We will invest in the S&T that will allow us to simplify DCRi capabilities, allowing them to be brought forward to the POI. We will seek simplification and forward deployment of endovascular torso hemorrhage control, improved blood resuscitation solutions, and organ support devices with inflammatory modulation technology. We will leverage rapidly emerging and developing unmanned vehicle technology for capability delivery and eventually self-sustained casualty care and evacuation platforms.

SUMMARY

In summary, sustained investment in CCC research will keep the US military’s combat casualty care ahead of the curve for future operational challenges. The JTS encompasses the full continuum of trauma care from TCCC at the POI and during medical evacuation to damage control resuscitation and surgery at Role 2 and 3 to long range global evacuation of the critically injured to Role 4 care and to definitive care facilities in the United States. It should, therefore, be solidified into joint doctrine as a standing organization. The JTS manages all aspects of a global military trauma system to optimize casualty care in theaters of war and in increasingly complex operational environments around the world.

The Combat Casualty Care Research Program manages the combat casualty care research equity for the Department of Defense. Similarly, the United States would benefit from a more robust national investment in trauma care guided by a national research action plan. Military-civilian partnerships within national trauma organizations, surgical societies, and civilian academia would foster a model of collaborative training and research with common goals that would benefit both the US military and the civilian population.

REFERENCES

1. *The U.S. Army Operating Concept: Win in a Complex World 2020-2040*. Fort Eustis, Virginia: US Army Training and Doctrine Command; October 31, 2014. TRADOC Pamphlet 525-3-1. Available at: http://minerva.dtic.mil/doc/McMaster_AOC_full.pdf. Accessed January 20, 2016.
2. Rasmussen TE, Gross KR, Baer DG. Where do we go from here?. *J Trauma*. 2013;75(suppl 2):S105-S106.
3. Holcomb JB, McMullin NR, Pierce L, et al. Causes of death in US Special Operations Forces in the Global War on Terrorism 2001-2004. *Ann Surg*. 2007;245:986-991.
4. Kelly JF, Ritenour AE, McLaughlin DF, et al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 versus 2006. *J Trauma*. 2008;64:S21-S27.
5. Eastridge BJ, Jenkins D, Flaherty S, et al. Trauma system development in a theater of war: experiences from Operation Iraqi Freedom and Operation Enduring Freedom. *J Trauma*. 2006;61:1366-1373.
6. Haas B, Jurkovich GJ, Wang J, et al. Survival advantage in trauma centers: expeditious intervention or experience? *J Am Coll Surg*. 2009;208:28-36.
7. Celso B, Tepas J, Langeland-Orban B, Pracht E, Papa L, Lottenberg L, Flint L. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *J Trauma*. 2006;60:371-378.
8. MacKenzie EJ, Rivara FP, Jurkovich GJ, et al. A national evaluation of the effect of trauma-center care on mortality. *N Engl J Med*. 2006;354:366-378.
9. Barringer ML, Thomason MH, Kilgo P, Spallone L. Improving outcomes in a regional trauma system: impact of a level III trauma center. *Am J Surg*. 2006;192:685-689.
10. Nathens AB, Jurkovich GJ, Maier RV, Grossman DC, MacKenzie EJ, Moore M, Rivara FP. Relationship between trauma center volume and outcomes. *JAMA*. 2001;285:1164-1171.
11. Bailey J, Spott MA, Costanzo GP, Dunne JR, Dorlac W, Eastridge B, eds. *Joint Trauma System: Development, Conceptual Framework, and Optimal Elements*. JBSA Fort Sam Houston, TX: US Army Institute for Surgical Research; 2012. Available at: http://www.usaisr.amedd.army.mil/pdfs/Joint_Trauma_System_final_clean2.pdf. Accessed January 20, 2016.

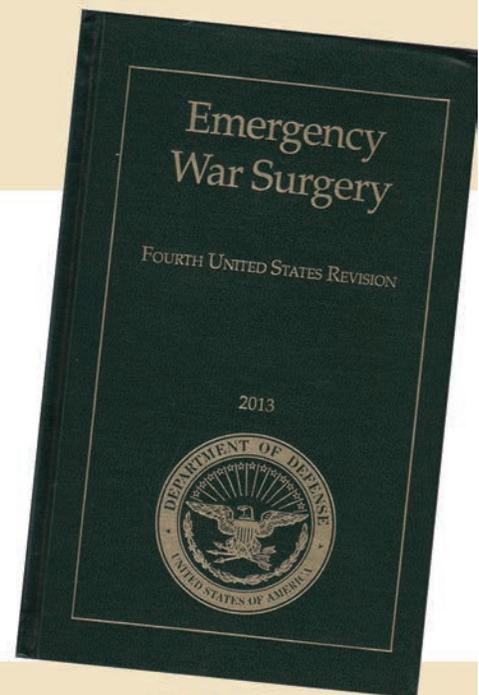
12. *AJP-4.10(A) Allied Joint Medical Support Doctrine*. Brussels, Belgium: North Atlantic Treaty Organization; May 2011:1-8 through 1-13.
13. Sauer SW, Robinson JB, Smith MP, et al. Saving lives on the battlefield (part II): one year later a Joint Theater Trauma System and Joint Trauma System review of prehospital trauma care in Combined Joint Operations Area–Afghanistan (CJOA-A) Final Report, 30 May 2014. *J Spec Oper Med*. 2015;15(2):25-41.
14. Morrison JJ, Oh J, DuBose JJ, et al. En-route care capability from point of injury impacts mortality after severe wartime injury. *Ann Surg*. 2013;257:330-334.
15. Mabry RL, Apodaca A, Penrod J, et al. Impact of critical care-trained flight paramedics on casualty survival during helicopter evacuation in the current war in Afghanistan. *J Trauma*. 2012;73:S32-S37.
16. Borgman MA, Spinella PC, Perkins JG, et al. The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. *J Trauma*. 2007;63:805-813.
17. Holcomb JB, Tilley BC, Baraniuk S, et al. Transfusion of plasma, platelets, and red blood cells in a 1:1:1 vs a 1:1:2 ratio and mortality in patients with severe trauma - the PROPPR Randomized Clinical Trial. *JAMA*. 2015;313:471-482.
18. Dente CJ, Shaz BH, Nicholas JM, et al. Improvements in early mortality and coagulopathy are sustained better in patients with blunt trauma after institution of a massive transfusion protocol in a civilian level I trauma center. *J Trauma*. 2009;66:1616-1624.
19. Zink KA, Sambasivan CN, Holcomb JB, et al. A high ratio of plasma and platelets to packed red blood cells in the first 6 hours of massive transfusion improves outcomes in a large multicenter study. *Am J Surg*. 2009;197:565-570.
20. Duchesne JC, Hunt JP, Wahl G, et al. Review of current blood transfusions strategies in a mature level I trauma center: were we wrong for the last 60 years? *J Trauma*. 2008;65:272-278.
21. Morrison JJ, DuBose JJ, Rasmussen TE, Midwinter MJ. Military Application of Tranexamic Acid in Trauma Emergency Resuscitation (MATTERs) Study. *Arch Surg*. 2012;147(2):113-119.

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EMERGENCY WAR SURGERY 4TH US REVISION

As an update to the much-referenced 2004 version, information in this edition reflects lessons learned from American involvement in Iraq and Afghanistan, and represents state-of-the-art principles and practices of forward trauma surgery. This publication expertly addresses the appropriate medical management of blast wounds, burns, multiple penetrating injuries, as well as other battle and nonbattle injuries. Topics include triage, hemorrhage control, airway/breathing, shock and resuscitation, anesthesia, infections, critical care, damage control surgery, face and neck injuries, soft-tissue injuries, ocular injuries, head injuries, extremity fractures, thoracic injuries, amputations, abdominal injuries, pediatric care, and more.



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Infection Prevention in the Deployed Environment

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ABSTRACT

Up to 50% of combat injured patients from recent conflicts have suffered infectious complications, predominantly with multidrug-resistant (MDR) bacteria acquired nosocomially in the chain of tactical combat casualty care. These bacteria have ranged from MDR *Acinetobacter baumannii-calcoaceticus* associated with Operation Iraqi Freedom (OIF), to extended spectrum beta-lactamase producing *Enterobacteriaceae* from operations in Afghanistan. Experience from interventions at Level III facilities demonstrate that basic infection control (IC) procedures, such as improvements in hand hygiene, use of ventilator associated pneumonia bundles, and antimicrobial stewardship, can improve outcomes even in austere environments. While some systematic interventions have been implemented to mitigate this risk, including development of the Deployed Infection Control Course, the Multidrug-Resistance Surveillance Network, and the Trauma Infectious Disease Outcomes Study, ongoing vulnerabilities remain. Deployed microbiology capabilities should be strengthened, theater-level IC standard operating procedures should be implemented, and a joint, theater-level expert IC consultant should be appointed to be responsible for directing IC activities from Levels I to IV.

Throughout history, infectious complications have reliably followed combat injuries. Increased survival rates from recent conflicts have resulted in increasing numbers of seriously injured patients who are at high risk for postinjury infections. Recent data demonstrated a 27% rate of infectious complications in combat-injured US troops evacuated to a Level V facility; this number increases to 50% among intensive care unit (ICU) patients.¹ These have predominantly involved multidrug-resistant (MDR) pathogens, including *Acinetobacter baumannii-calcoaceticus* (ABC), extended-spectrum beta-lactamase (ESBL) producing *Escherichia coli* and *Klebsiella pneumoniae*, and MDR *Pseudomonas aeruginosa* and *Enterobacter* spp. By definition, these are healthcare associated infections (HAI), since they present during the course of medical care and were not present or incubating on admission. These remain one of the leading causes of preventable death in this population, and lead to prolonged hospitalizations, repeat operative takebacks, and amputations. Observations from recent conflicts provide 5 categories of generalizable knowledge which can be applied to current and future operations.

LESSON #5. IF IT INVOLVES MDR GRAM-NEGATIVE BACTERIA, IT IS PROBABLY HEALTHCARE ASSOCIATED

Soon after combat operations began in Iraq in Afghanistan, clinicians caring for casualties in Level IV and V facilities observed the unusual occurrence of MDR gram-negative rods (GNR) causing wound infections, osteomyelitis, pneumonia, and bloodstream infections. The first publication described 102 patients

from 2002-2004 with bloodstream infections caused by ABC.² These were identified at military hospitals treating combat casualties from Iraq and Afghanistan, and 83% were associated with OIF and Operation Enduring Freedom (OEF). Three major hypotheses were formulated as to the source of these bacteria: pre-injury colonization with resistant organisms (presumably as a result of climate differences, austere environments; changes in personal hygiene during deployment); direct inoculation by contaminated soil/debris at the time of injury; or via nosocomial transmission.

Numerous studies evaluated the potential role of pre-injury colonization with MDR ABC and/or environmental contamination as the source. These included an assessment of colonization of Army medic trainees who had never deployed or come into patient contact, in patients evacuated from theater for disease nonbattle injury, and in uninjured troops during deployment.³⁻⁵ None demonstrated pre-injury colonization with MDR ABC. Evaluations of fresh wounds were also performed at the time of injury; these demonstrated predominantly skin flora with no evidence of MDR GNR.⁶ Soil specimens were collected at various sites across Iraq and Afghanistan; no MDR pathogens were demonstrated, and the GNR which were isolated from wet soil samples in Afghanistan were genotypically unrelated to those characterized from infected combat casualties.⁷

However, genotypic analysis of ABC demonstrated some consistent strains identified from Levels III to V;

these have also been recovered from British and Canadian combat casualties.^{5,8} While clinical cultures from US troops in a Level III grew predominantly gram-positives, those recovered from local nationals admitted in the same facility were disproportionately represented by ABC, *K. pneumoniae*, and *P. aeruginosa*.⁹ Level III hospital census and the local national length of stay correlated with the ABC colonization rate.¹⁰ It was also demonstrated that in both Iraq and Afghanistan, local patients are frequently colonized with MDR GNR during the course of hospitalization, including high rates on admission.^{11,12} Taken together, these data demonstrate that the predominant source of MDR GNR colonization and healthcare associated infection in US combat casualties is nosocomial. This means that a fatalistic attitude about infectious complications cannot be assumed, and places responsibility on the chain of tactical combat casualty care to minimize this risk through careful attention to IC precautions.

LESSON #4. DIFFERENT THEATERS, DIFFERENT KINETICS, DIFFERENT ORGANISMS

When one pathogen eclipses others in order of importance, there is a tendency to drive research and interventions at that specific pathogen; in IC literature this is termed a “vertical” approach. ABC was the predominant organism through OIF, garnered much media and political attention as “Iraqibacter”, and most of the first 5 years of research focused on this pathogen specifically. Returning combat casualties were screened for colonization with ABC on arrival at Levels IV and V, and overall colonization rates began to downtrend after 2006, initially appearing to indicate success. However, when in 2008 active surveillance was expanded to include other MDR pathogens, it became clear that colonization rates remained fairly stable in the range of 15% (Level V).¹³ With the shift in major combat operations from Iraq to Afghanistan, the predominant pathogen changed to ESBL producing *E coli* and other *Enterobacteriaceae*. Additionally, with changes in tactics and increased frequency of dismounted patrols in the provinces of southern Afghanistan, the mechanisms of injury changed to include higher traumatic above the knee amputations and major complex blast injuries, setting the stage for emergence of invasive fungal infections in the 2009-2010 timeframe.¹⁴ The implication of these changes in microbiology with changes in theater and kinetics is that broad assumptions about empiric therapy and vertical IC measures (such as screening and decolonization for one organism or another) are likely to be dated and met with limited success. It also means that microbiology expertise in the deployed environment must be available and supported, so that changes in microbiology can be met with real-time interventions such as changes in

prophylaxis and empiric therapy. A flexible approach to prevention is necessary, both by incorporating lessons learned and maintaining relevant research such that interventions can be focused.

LESSON #3. EXPERTISE MUST BE DEVELOPED AND DEPLOYED

The IC community in the Department of Defense (DoD) is a small one, largely consisting of a handful of nearly exclusively civilian IC officers assigned to Level IV and US-based MTFs, and a few active duty infectious disease physicians who have experience as medical directors of IC at their hospitals. Level III facilities currently task one nurse with directing IC activities as an additional duty, but this individual rarely has prior experience. In 2008, in order to provide directed training to those deploying in this role, the Infection Control in the Deployed Environment Course was developed and initiated through the Army Medical Department Center & School at Brooke Army Medical Center (BAMC).¹⁵ In 2010, an Army Execution Order was published directing that one person be identified to perform this duty at Level IIIs and to ensure predeployment training. Uptake of predeployment training was irregular by Air Force personnel deploying in this role until 2012. Current records dating from 2011 indicate that 89 Army (77 active, 12 reserve), 18 Air Force (16 active, 2 reserve), 1 Navy, 2 Canadian military and 6 civilian personnel have attended the course, with deployments to Afghanistan (40), Kuwait (11), and several to Africa, Central and South America (R. SantaMaria, unpublished data). We recommend that this course (or equivalent) be mandated for those deploying to Level III facilities in the role of IC officer. Serious consideration should also be given to the general structure of the IC community in the DoD with regard to the authorized numbers of active duty, certified infection preventionists. Ideally, those deploying in the role would have experience in the field. Additionally, while telehealth support exists for IC through Army Knowledge Online email consults, this currently exists as a question-answering service. It would be strengthened by expanding its role to include a proactive fact-finding and active mentoring component, ideally helmed by a joint, theater-level consultant with accountability and authority to develop and direct infection prevention activities theater-wide.

LESSON #2. SYSTEMS FOR RESEARCH AND SURVEILLANCE MUST BE IN PLACE AND ONGOING

The “Iraqibacter” crisis during OIF demonstrated the absence of a systematic, structured approach to capturing combat-related infection events or organisms for characterization. Although this need was quickly recognized, multiple barriers toward meeting research gaps existed, including logistical and legal constraints related

to performing operational research. For years, research was limited to retrospective data analyses performed after a proactive clinician's deployment, or collected outside the combat zone altogether and performed in a fragmented fashion by different investigators in different organizations, limiting generalizability. The Army ultimately arranged some deployments specifically for research, including infectious disease research, and the DoD Trauma Registry (DoDTR) was modified to better capture infectious disease events. In 2008, the first set of clinical practice guidelines relating to prevention of infection in combat casualties was published, and a significant update was published in 2011 and endorsed by the Surgical Infection Society and the Infectious Disease Society of America.¹⁶ In 2009, the Trauma Infectious Disease Outcomes Study (TIDOS), a project of the Infectious Disease Clinical Research Program, was initiated and began prospectively enrolling evacuated combat casualties. At the same time, the Multidrug-resistant Organism Repository and Surveillance Network began collecting isolates to evaluate relatedness and resistance, and conduct global molecular epidemiology. The first generalizable knowledge extracted from either of these, however, was 2011, approximately 9 years into combat operations. Systems such as these require ongoing funding and support even in the interconflict period to prevent similar delays in the next conflict.

LESSON #1. THE STATUS QUO IS UNACCEPTABLE; BUT IC MEASURES ARE EFFECTIVE IN THE OPERATIONAL ENVIRONMENT

As previously stated, 27% to 50% of US casualties evacuated from the combat zone develop HAI (National Healthcare Safety Network-defined), an astonishingly high rate for largely preventable complications, with serious effect on these patients.¹ Direct comparison to HAI in US-based civilian trauma is challenging based on different mechanisms of injury and population as well as methodologies of TIDOS versus other prospective trauma infectious disease studies. However, trauma registry studies were conducted out of BAMC, a Level I trauma center, and the DoDTR, with nearly identical methodologies. The BAMC study, which excluded combat casualties, demonstrated an 8% infection rate vs the DoDTR study, which demonstrated infection in one-third of subjects.^{17,18} Notably, the DoDTR's median injury severity score was higher, but the population at BAMC was older and had a higher proportion of medical comorbidities. Infections in combat casualties occur a median of 7 days after injury, well after evacuation out of theater. Therefore, the practitioners in Level II and III facilities may remain largely unaware of the complications their patients are developing, and attitudes toward IC in theater may be similarly uninformed.¹

Fortunately, basic IC interventions are effective in the operational environment, just as they are in garrison. A study evaluating the effects of basic interventions including hand hygiene attention and surveillance, implementation of ventilator-associated pneumonia (VAP) bundles, and antimicrobial stewardship, was performed by Landrum et al¹⁹ at Balad Air Force Theater Hospital, Iraq. At the time, this facility was a series of interconnected tents. This demonstrated a rapid reduction in the VAP rate from 60 to 11 per 1000 ventilator days and improvement in the facility's antibiogram, with improvements in ABC susceptibility to both amikacin and meropenem. In 2011, similar interventions were conducted at Craig Joint Theater Hospital, Bagram, Afghanistan, during OEF's peak in combat casualties, with approximately 600 ICU patients treated from June to December. With basic interventions such as ensuring widespread availability of alcohol-based hand rub and conducting hand hygiene surveillance, we observed an increase in adherence from 28% to 80% in the ICU in one month which was sustained over those 6 months. The VAP rate was reduced from 40 to 13 per 1000 ventilator days over the course of 6 months; both these were sustained at 6-month follow up in 2012. Adherence to CPG recommendations for antimicrobial prophylaxis was evaluated, with feedback given locally in areas of concern, and the admission overprint revised to guide more appropriate prescribing. Theater-wide errors in microbiology reporting of ESBL producing pathogens were also detected and corrected, and antibiograms revised accordingly (H. C. Y., unpublished data).

However, there is considerable room for progress in the formulation and implementation of IC policies and procedures in the operational environment. Successful interventions have been fragmented, limited to one hospital or another at various times, and often "targets of opportunity" driven by clinicians deployed for other purposes. Dedicated deployments of experts in 2008, 2009, and 2012 to assess IC demonstrated ongoing inconsistencies in a number of areas. These included pre-deployment training of IC officers; development and application of theater-wide IC and bloodborne pathogen exposure policies; deployed microbiology capabilities; and contracts, supplies, and equipment relating to IC and hospital cleaning. It is also clear from experience that if little attention is paid to IC during stability operations, even less may be present during entry. These represent ongoing threats and vulnerabilities.

RECOMMENDATIONS

Recommendations about further investment in IC have been previously published and are summarized in the Table. These relate to command support and administrative

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Specific Infection Prevention Areas for Prioritization in Deployed Military Treatment Facilities.*	
Focus area	Recommendation
Command Support/ Administrative Controls	<ul style="list-style-type: none"> • Establish joint, theater-level expert consultant responsible for directing IC activities from Levels I-IV, including annual risk assessments and plans. • Establish theater-level IC SOPs. • Commit to deployed expert microbiology support and integrated surveillance for HAIs and MDROs. • Commit to ongoing education for deploying and deployed infection preventionists and clinicians. • Commit to resourcing clinically relevant IC/HAI research in theater. • Commit to resourcing updated clinical practice guidelines.
Essential IC Tactical Priorities	<ul style="list-style-type: none"> • Follow national and international guidelines for prevention and treatment of HAI. • Implement robust hand hygiene programs and monitor adherence. • Implement VAP bundles and monitor adherence. • Implement evidence-based SSI prevention measures. • Emplace BBP occupational exposure protocols and ensure available prophylaxis. • Ensure cohorting of short-term vs long-term patients. • Standardize environmental disinfection, including both low- and high-level disinfection, and processing of sterile supplies. • Implement antimicrobial stewardship programs and monitor adherence with published guidelines.

*Data source: Hospenthal et al.²⁰
 IC indicates infection control; SOP, standard operating procedure; HAI, healthcare-associated infection; MDRO, multidrug-resistant organism; VAP, ventilator-associated pneumonia; SSI, surgical site infection; BBP, bloodborne pathogen.

controls, and offer a view to prioritization of specific interventions. However, our most primary recommendation moving forward relates to leadership: we support development of a systematic, command-supported process to address IC in the deployed environment. This would be best accomplished through establishing a joint, theater-level consultant with the skills and experience to develop theater-level standard operating procedures, perform annual risk assessments and plans, coordinate with microbiology capabilities, establish theater-level antibiograms, conduct surveillance, support deployed IC officers, communicate with commanders, and assist with related research and quality improvement projects.

REFERENCES

1. Tribble DR, Conger NG, Fraser S, et al. Infection-associated clinical outcomes in hospitalized medical evacuees after traumatic injury: trauma infectious disease outcome study. *J Trauma*. 2011;71:S33-S42.
2. Centers for Disease Control and Prevention. Acinetobacter baumannii infections among patients at military medical facilities treating injured U.S. service members, 2002-2004. *MMWR Morb Mortal Wkly Rep*. 2004;53:1063-1066.
3. Griffith ME, Ceremuga JM, Ellis MW, Guymon CH, Hospenthal DR, Murray CK. Acinetobacter skin colonization of US Army Soldiers. *Infect Control Hosp Epidemiol*. 2006;27:659-661.
4. Griffith ME, Lazarus DR, Mann PB, Boger JA, Hospenthal DR, Murray CK. Acinetobacter skin carriage among US army soldiers deployed in Iraq. *Infect Control Hosp Epidemiol*. 2007;28:720-722.
5. Scott P, Deye G, Srinivasan A, et al. An outbreak of multidrug-resistant Acinetobacter baumannii-calcoaceticus complex infection in the US military health care system associated with military operations in Iraq. *Clin Infect Dis*. 2007;44:1577-1584.
6. Murray CK, Roop SA, Hospenthal DR, et al. Bacteriology of war wounds at the time of injury. *Mil Med*. 2006;171:826-829.
7. Keen EF III, Mende K, Yun HC, et al. Evaluation of potential environmental contamination sources for the presence of multidrug-resistant bacteria linked to wound infections in combat casualties. *Infect Control Hosp Epidemiol*. 2012;33:905-911.
8. Turton JF, Kaufmann ME, Gill MJ, et al. Comparison of Acinetobacter baumannii isolates from the United Kingdom and the United States that were associated with repatriated casualties of the Iraq conflict. *J Clin Microbiol*. 2006;44:2630-2634.
9. Yun HC, Murray CK, Roop SA, Hospenthal DR, Gouridine E, Dooley DP. Bacteria recovered from patients admitted to a deployed U.S. military hospital in Baghdad, Iraq. *Mil Med*. 2006;171:821-825.
10. Griffith ME, Gonzalez RS, Holcomb JB, Hospenthal DR, Wortmann GW, Murray CK. Factors associated with recovery of Acinetobacter baumannii in a combat support hospital. *Infect Control Hosp Epidemiol*. 2008;29:664-666.
11. Sutter DE, Bradshaw LU, Simkins LH, et al. High incidence of multidrug-resistant gram-negative bacteria recovered from Afghan patients at a deployed US military hospital. *Infect Control Hosp Epidemiol*. 2011;32:854-860.

PROGRAMMATIC IMPLEMENTATIONS TO IMPROVE HEALTH

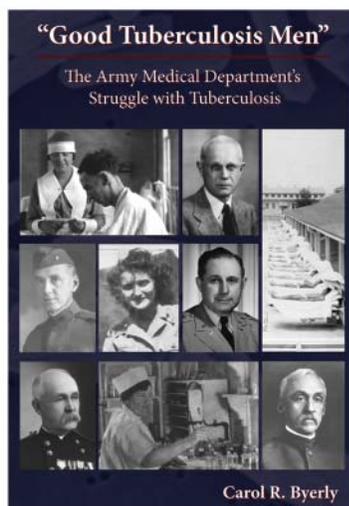
12. Ake J, Scott P, Wortmann G, et al. Gram-negative multidrug-resistant organism colonization in a US military healthcare facility in Iraq. *Infect Control Hosp Epidemiol.* 2011;32:545-552.
13. Hospenthal DR, Crouch HK, English JF, et al. Multidrug-resistant bacterial colonization of combat-injured personnel at admission to medical centers after evacuation from Afghanistan and Iraq. *J Trauma.* 2011;71:S52-S57.
14. Warkentien T, Rodriguez C, Lloyd B, et al. Invasive mold infections following combat-related injuries. *Clin Infect Dis.* 2012;55:1441-1449.
15. Crouch HK, Murray CK, Hospenthal DR. Development of a deployment infection control course. *Mil Med.* 2010;175:983-989.
16. Hospenthal DR, Murray CK, Andersen RC, et al. Guidelines for the prevention of infections associated with combat-related injuries: 2011 update: endorsed by the Infectious Diseases Society of America and the Surgical Infection Society. *J Trauma.* 2011;71:S210-S234.
17. Murray CK, Wilkins K, Molter NC, et al. Infections in combat casualties during Operations Iraqi and Enduring Freedom. *J Trauma.* 2009;66:S138-S144.
18. Yun HC, Blackbourne LH, Jones JA, et al. Infectious complications of noncombat trauma patients provided care at a military trauma center. *Mil Med.* 2010;175:317-323.
19. Landrum ML, Murray CK. Ventilator associated pneumonia in a military deployed setting: the impact of an aggressive infection control program. *J Trauma.* 2008;64:S123-S127; discussion S127-S128.
20. Hospenthal DR, Green AD, Crouch HK, et al. Infection prevention and control in deployed military medical treatment facilities. *J Trauma.* 2011;71:S290-S298.

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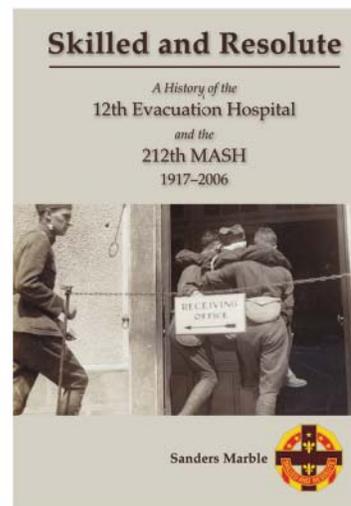
"GOOD TUBERCULOSIS MEN" THE ARMY MEDICAL DEPARTMENT'S STRUGGLE WITH TUBERCULOSIS



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Medical Logistics Lessons Observed During Operations Enduring Freedom and Iraqi Freedom

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ABSTRACT

Medical Logistics (MEDLOG) is a function of the Army's integrated System for Health that provides the medical products and specialized logistics services required to deliver health protection and care under all operational conditions. In unified land operations, MEDLOG is an inherent function of Health Service Support (HSS), which also includes casualty care and medical evacuation. This paper focuses on a few key lessons observed during Operations Enduring Freedom and Iraqi Freedom with direct implications for the support of HSS in future operations as envisioned in the Army Operating Concept and the Joint Concept for Health Services. It also examines a few key enablers that helped mitigate these challenges that are not yet fully acknowledged in Army Medical Department doctrine, policy, and planning.

Healthcare delivery relies intensively on medical products and specialized logistics services provided by medical logistics (MEDLOG). Under the best of conditions, MEDLOG is a complex and challenging discipline. In unified land operations, the demands of Health Service Support (HSS) and the nature of its materiel requirements have resulted in common observations as far back as the American Civil War¹:

- ▶ Preferred medications were not on table of supplies.
- ▶ Military doctors lacked knowledge of military procedures.
- ▶ Transportation of medical materiel had low priority.
- ▶ Medical supplies were left behind in order not to affect movement.
- ▶ Equipment and supplies were required to care for indigent volunteers, displaced persons, and refugees.

After a decade of HSS support during Operations Enduring and Iraqi Freedom (OEF/OIF), there are numerous examples of Army MEDLOG challenges as well as accomplishments. In particular, experiences during the early days of these conflicts—before mature forward operating bases could sustain communications and distribution channels—may be especially relevant to the future operating environment envisioned in the *Army Operating Concept* (AOC)² and the *Joint Concept for Health Services* (JCHS).³

MEDICAL LOGISTICS CHALLENGES

The following observations from OEF/OIF demonstrate the complexity of medical logistics, its need for agility

to respond to the dynamic demands of HSS operations, the perishability of MEDLOG skills, and its often low priority in planning and/or in expeditionary operations.

Modularity

The Army medical capabilities deployed into Kuwait, Afghanistan, Iraq, and the Horn of Africa included sophisticated medical technologies distributed across the battle space in small, modular elements. Combat support hospitals and forward surgical teams, regardless of formal organization, were split-based into 2 or more operating locations with varying support relationships. This means of employment is consistent with the future operating environment described in the AOC and JCHS, where joint forces will be expected to deploy long distances to and from dispersed locations and operate in often austere and contested environments. The need for redundancy in equipment to support such modularity, both clinical and logistical (eg, power, shelter, mobility), will be considered in Army Medical Department (AMEDD) force design updates; however, the implications for synchronizing and delivering medical supplies and maintenance support are equally profound. In OEF/OIF, small and dispersed medical elements generated significant, specialized supply and maintenance demands but had limited self-sufficiency and minimal (if any) organic personnel to manage logistics. Future medical capabilities, especially at the prehospital levels, will likely incorporate even more advanced trauma management capability with associated specialized logistics requirements. This has major implications for the theater HSS system's ability to gain visibility of MEDLOG

requirements, make timely and informed decisions for prioritization, and allocate necessary resources through available distribution channels.

Variation

The majority of OEF/OIF medical materiel demands did not match items in unit medical assemblages or the Class VIII (medical) supplies prepositioned in the theater to sustain those assemblages. Allowance standards for Army medical assemblages are designed to provide specific capabilities for 72 hours of combat operations. During 2003, only 32% of Class VIII demands generated by joint medical forces matched the Medical Contingency File, a database maintained by the Defense Logistics Agency (DLA) listing supply items in the military services' medical allowance standards.⁴ As a consequence, medical units commenced line item ordering of additional, unanticipated items almost immediately upon arrival in theater. Based on the authors' observations, medical units' demands for materiel above allowance standards began during joint reception, staging, and onward integration (JRSOI) when demands were predominantly driven by primary care to US personnel, and continued with the advent of casualty care. Unit allowance standards were particularly inadequate for the breadth of patient populations treated; eg, enemy prisoners of war, displaced persons, and other civilians, especially children. Similarly, unit assemblages did not accommodate the preference/experience of initial and rotating clinicians, particularly for specialized capabilities such as neurosurgery. Furthermore, the processes for service-specific joint urgent operational needs introduced additional medical technologies with minimal consideration for theater standardization, repair parts, or maintenance training. Given the operational and financial constraints in medical set design, it is unlikely unit assemblages can ever meet the breadth of medical materiel requirements associated with the range of possible HSS missions; yet there will continue to be little tolerance for failure in meeting these requirements. This has significant implications for the AMEDD's ability to anticipate, identify, and respond to medical supply and maintenance requirements beyond the initial capabilities offered by unit allowance standards.

Perishable Skills

Medical logistics is a skilled discipline that requires experience to maintain competence in systems, procedures, and problem solving. Given the modular and dispersed nature of current MEDLOG capabilities, there are limited opportunities for technical mentorship of deployed logisticians as well as for nonlogisticians who must engage the logistics system for support. In the early months of OEF/OIF, it was clear that home station training and

experience did not adequately prepare Soldiers and units to meet the MEDLOG challenges of actual HSS operations. Garrison tasks for medical units are generally limited to set maintenance, with little exposure to the dynamics of sustaining healthcare operations. Few, if any, Army medical logistics companies have opportunities to perform supply support activity functions while at their home station. As a consequence, the authors observed that many MEDLOG Soldiers (and leaders) arrived unprepared to connect and use automated systems and instead relied on manual (such as paper, phone, or email) processes. The US HSS assessment conducted in 2011 in the Afghanistan combined joint operations area also noted the need for rigorous professional development for medical logisticians through active garrison mission or more specialized training.⁵ The nature of the future operating environment and rapid employment of modular, highly sophisticated medical capabilities have significant implications for maintaining ready skills of medical logisticians to quickly establish and synchronize medical supply and maintenance support.

Priority

Medical materiel frequently did not have sufficient priority to compete for available transportation. Although OEF/OIF distribution channels ultimately became sufficiently robust that MEDLOG priority was seldom an issue, this was not the case in 2003 when MEDLOG capabilities as well as materiel often experienced lower priority for movement in both strategic and intratheater channels. The MEDLOG battalion with the mission to establish Class VIII distribution for JRSOI arrived in Kuwait with capabilities needed to receive cold chain and controlled substances barely 10 days before the invasion commenced on March 19. This created backlogs in the United States and Europe for planned shipments of pharmaceuticals, vaccines, and laboratory reagents, and further burdened strategic air channels with additional medical materiel needed to support healthcare to gathering forces. A lower priority for medical materiel could be attributed to the fact that combat and combat support capabilities, as well as commodities such as ammunition, repair parts, food, and water routinely have transportation precedence as mission commanders build and sustain combat power. However, the lack of medical priority often resulted because mission commanders did not have sufficient awareness of the actual state of medical readiness. A contributing reason was a lack of Class VIII visibility in logistics systems used for Army sustainment; however, status reporting by medical units frequently did not reflect medical supply or maintenance as constraints for mission readiness. In future operations, US forces may not have uncontested access into an area of operations or ready availability of

commercial carriers; therefore, competition for distribution resources will likely remain the norm throughout all phases of operations. This has significant implications for the AMEDD's ability to identify and manage its requirements in order to optimize use of available distribution resources, and to provide accurate and timely situational awareness of medical materiel constraints to mission commanders who set movement priorities.

MEDICAL LOGISTICS ACCOMPLISHMENTS

Prior to 2002, there was no MEDLOG infrastructure in the US Central Command (CENTCOM) for sustaining HSS in land operations. The 3rd Medical Command (Deployment Support (DS)), as the senior Army medical mission command for the 3rd US Army, was tasked to plan and execute single integrated medical logistics management responsibilities for the support of joint medical forces. The Medical Materiel Readiness Assessment conducted in 2007 for the DLA provides a succinct overview of how the 3rd Medical Command (MEDCOM) (DS) established and adapted MEDLOG support from theater opening through the beginning of the "surge" in 2007.⁶

Despite the significant challenges, the AMEDD was remarkably successful in its MEDLOG support of Army and joint medical forces during OEF/OIF. The dedication and skill of medical logisticians across the force were indispensable in establishing a responsive and agile support framework; however, of equal importance were a few key decisions and enablers not yet fully acknowledged in AMEDD doctrine, policy, and planning.

6th Medical Logistics Management Center

The 3rd MEDCOM effectively used the 6th Medical Logistics Management Center (MLMC) to establish a responsive, adaptable, and enduring framework for theater MEDLOG support. The MLMC provided senior, skilled leadership to organize and establish a provisional medical materiel center (MMC), the US Army Medical Materiel Center, Southwest Asia (USAMMC-SWA) to serve as a theater-level platform for the intratheater medical supply chain and maintenance support. The 3rd MEDCOM facilitated this by assigning the MLMC commander (grade O6) operational control of 2 MEDLOG battalions (388th and 428th) to allow optimal allocation of personnel and skills between a primary theater distribution center in Qatar and a forward distribution point for JRSOI in Kuwait. While USAMMC-SWA manning has changed consistent with the Army's theater posture, it continues to serve as a provisional organization, commanded by a medical logistician (grade O5). The USAMMC-SWA still provides CENTCOM a stable and capable platform for managing intratheater distribution

of critical Class VIII supplies, including cold chain and controlled substances, and for staging specialized medical maintenance capabilities provided by the US Army MEDCOM. Experiences in OEF/OIF demonstrated the importance of an AMEDD capability to establish a theater MMC, led by senior medical logisticians, to effectively open and sustain HSS in distant land theaters. With the removal of medical logistics battalions from the AMEDD force structure, the 6th MLMC's modular, theater-aligned organization and centralized MEDLOG management mission are critically important for projecting this capability. This important role may be implied, but is not specifically reflected in Army MEDLOG doctrine.

Medical Supply Automation

Key medical logistics systems at user (DCAM^a) and enterprise (TEWLS^b) levels enabled an end-to-end supply chain between customers and theater/strategic Class VIII sources. In OEF/OIF, nearly all deployed medical units below theater hospital used DCAM to perform user-level Class VIII supply functions. In view of challenges previously discussed (modularity, variance, perishable skills), DCAM was valued for its simplicity (especially for use by nonlogistics personnel), access to supplier catalogs, and "store and forward" utility with intermittent communications. It should be noted that its most significant challenge, firewall barriers that impede access to communications networks, will soon be addressed using enterprise capabilities of the Defense Information Systems Agency. In 2009, the AMEDD replaced its legacy materiel management system at USAMMC-SWA with TEWLS, an enterprise resource planning solution integrating Class VIII management across all Army MMCs. The TEWLS enabled centralization of key medical materiel management functions and improved synchronization of data among customers, MMCs, and commercial suppliers. It also facilitated the balancing of stocks and workload driven by changes in theater operations between USAMMC-SWA and the US Army Medical Materiel Center-Europe (USAMMCE). These observations are not intended to endorse specific systems; rather, they highlight the enterprise capabilities critically needed by the AMEDD to effectively and efficiently manage MEDLOG in future HSS operations. The dispersion of small, highly sophisticated medical capabilities (including MEDLOG) will require logistics and nonlogistics personnel alike to have reliable access to MEDLOG information, and for theater logistics managers to have near real-time visibility of MEDLOG requirements and resources to optimize use of constrained

^aDefense Medical Logistics Standard Support Customer Assistance Module

^bTheater Enterprise Wide Logistics System

OPERATIONAL SYSTEM CHALLENGES

Key DOTMLPF ^a Implications for MEDLOG Lessons Observed.	
Doctrine and Policy	<ul style="list-style-type: none"> Recognize in AMEDD doctrine (eg, ATP 4-02.1^b) and policy (eg, AR 40-61^c) the role of key MEDCOM organizations (MMCs, USAMMA, Installation Medical Supply Activities) in direct support of operating forces. Recognize in AMEDD doctrine the requirement to establish, when necessary, a provisional MMC to provide theater-level MEDLOG, and the role of the MLMC in enabling that capability. Recognize in AMEDD doctrine the technical alignment of supply support functions provided by Army MEDLOG Companies with medical materiel management that is centralized at theater-level MMC or MLMC.
Training	<ul style="list-style-type: none"> Ensure rigorous professional development for medical logisticians through active garrison missions for MEDLOG units and medical proficiency training in the Army's Health Readiness Platforms.
Leader Development	<ul style="list-style-type: none"> Ensure leader development of medical mission commanders and staff promotes their ability to plan, manage, and appropriately advocate for MEDLOG support in HSS operations.
Materiel	<ul style="list-style-type: none"> Leverage existing and emerging enterprise information technologies to connect deployed medical elements with MEDLOG sustainment capabilities and enable effective management of theater MEDLOG requirements and resources.
^a Doctrine, organization, training, materiel, leadership & education, personnel, facilities ^b Army Techniques Publication 4-02.1: Army Medical Logistics ⁷ ^c Army Regulation 40-61: Medical Logistics Policies ⁸	

distribution channels. It will also require the ability to apply skilled management and technical oversight of MEDLOG capabilities distributed in companies and teams across the battlespace.

Theater Support by MEDCOM Organizations

Institutional (TDA^c) organizations of the US Army MEDCOM have provided CENTCOM critical MEDLOG capabilities in direct support of theater operations from the onset of OEF/OIF. The USAMMCE served as the strategic MEDLOG platform for opening the theater and assisted the 6th MLMC in establishing USAMMC-SWA. It remains in direct support of USAMMC-SWA, performing most materiel management functions including master data, customer order processing, and commercial supplier relations, as well as providing technical training for personnel rotating into USAMMCE-SWA and other key theater positions. The US Army Medical Materiel Agency (USAMMA) has provided specialized medical maintenance capabilities through Forward Repair & Maintenance-Medical teams as an extension of its national maintenance program. Also, during early phases of OEF/OIF, Army medical centers in the United States provided “reach” supply support for selected products required by clinical specialists, especially for neurosurgery and burn care. These observations are significant because they demonstrate essential MEDLOG capabilities that are not resident in operating forces; that is, Army and joint medical forces deployed in land operations will require MEDLOG capabilities provided only by Army MEDCOM’s institutional organizations. This direct support of operating forces by MEDCOM organizations leverages and extends business processes, systems, and supplier relationships honed for efficient peacetime operations in the

Department of Defense direct care system, and “blurs the line” between the AMEDD’s institutional and operating units and functions.

SUMMARY

These lessons from the opening phase of OEF/OIF highlight challenges applicable to HSS in future operations characterized by tailored, modular, medical forces operating far from sustaining capabilities in austere environments. They also demonstrate the importance of MEDLOG capabilities resident in institutional MEDCOM organizations to provide the operational reach and agility necessary to establish and sustain HSS in unified land operations. The key DOTMLPF^d implications of MEDLOG lessons observed from OIF/OEF are presented in the Table.

REFERENCES

1. Wichtendahl K. Dr. Jonathan Letterman: Father of Modern Emergency Medicine [internet]. National Museum of Civil War Medicine Website. Available at: <http://www.civilwarmed.org/letterman-dinner/letterman-father-of-battlefield-medicine/>. Accessed March 4, 2016.
2. *Army Operating Concept, TRADOC Pamphlet 525-3-1*. Fort Monroe, VA: US Army Training and Doctrine Command; October 31, 2014:15-19. Available at: <http://www.tradoc.army.mil/tpubs/pams/TP525-3-1.pdf>. Accessed March 4, 2016.
3. *Joint Concept for Health Services*. Washington, DC: Joint Staff, US Dept of Defense; August 31, 2015:2. Available at: http://dtic.mil/doctrine/concepts/joint_concepts/joint_concept_health_services.pdf. Accessed March 4, 2016.

^c Table of Distribution and Allowances: Prescribes the organizational structure, personnel and equipment authorizations, and requirements of a military unit to perform a specific mission for which there is no appropriate table of organization and equipment (the document which defines the structure and equipment for a military organization or unit).

^d Doctrine, organization, training, materiel, leadership & education, personnel, facilities

4. Cocrane RM, Mervis SA. *Medical Materiel Readiness Assessment*. Tysons, VA: Logistics Management Institute; October 2003: 3-8. Report DL207R1.
5. MEDCOM Support to ATO HSS Assessment: US Health Service Support Assessment Team. AN-NEX F to OPORD 12-01; October 20, 2011:22.
6. Addison D, Cocrane R, Costello P, Johnson M, Kissane J. *Medical Materiel Readiness Assessment (2007)*. Tysons, VA: Logistics Management Institute; May 2008:4-17,4-18. Report DL207R1.
7. *Army Techniques Publication 4-02.1: Army Medical Logistics*. Washington, DC: US Dept of the Army; October 29, 2015.
8. *Army Regulation 40-61: Medical Logistics Policies*. Washington, DC: US Dept of the Army; January 28, 2005.

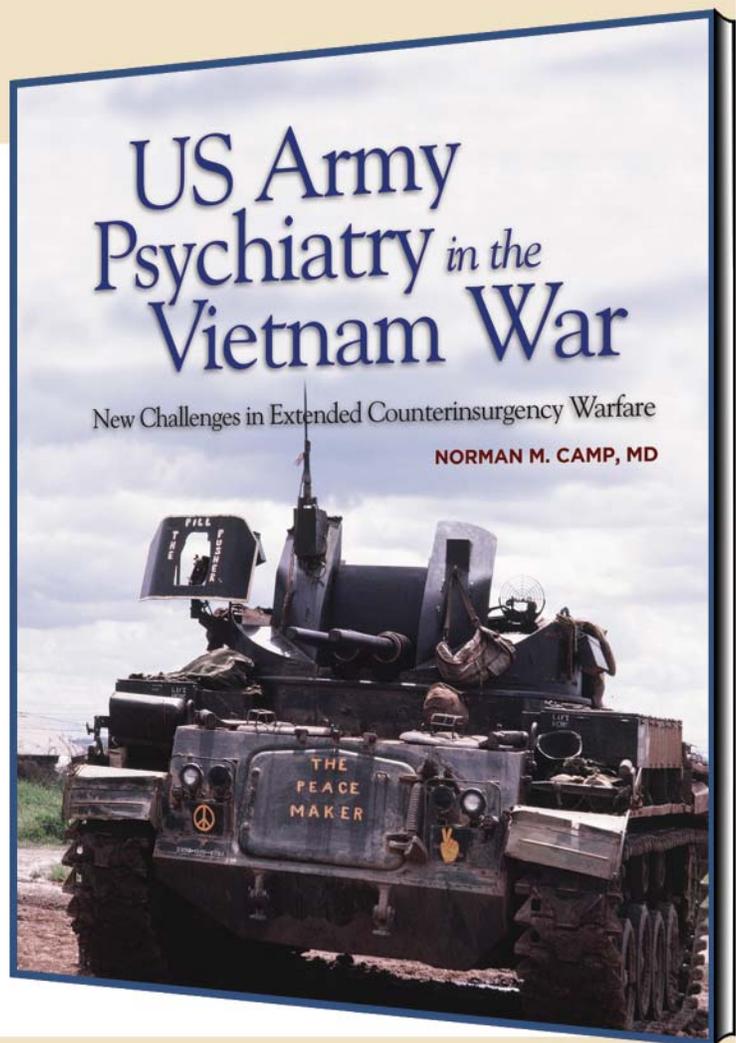
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During the Vietnam War (1965–1973), the US Army suffered a severe breakdown in soldier morale and discipline in Vietnam—matters that not only are at the heart of military leadership but also ones that can overlap with the mission of Army psychiatry. The psychosocial strain on deployed soldiers and their leaders in Vietnam, especially during the second half of the war, produced a wide array of individual and group symptoms that thoroughly tested Army psychiatrists and their mental health colleagues there. In the aftermath of the Vietnam War, the Army Medical Department apparently intended to sponsor a history of Army psychiatry along with other medical specialties, but that project was never begun. This book seeks to consolidate a history of the military psychiatric experience in Vietnam through assembling and synthesizing extant information from a wide variety of sources, documenting the successes and failures of Army psychiatry in responding to the psychiatric and behavioral problems that changed and expanded as the war became protracted and bitterly controversial.



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Planning Staff and Space Capacity Requirements during Wartime

Elisa B. Kepner, MSSE
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ABSTRACT

Determining staff and space requirements for military medical centers can be challenging. Changing patient populations change the caseload requirements. Deployment and assignment rotations change the experience and education of clinicians and support staff, thereby changing the caseload capacity of a facility. During wartime, planning becomes increasingly more complex. What will the patient mix and caseload volume be by location? What type of clinicians will be available and when? How many beds are needed at each facility to meet caseload demand and match clinician supply? As soon as these factors are known, operations are likely to change and planning factors quickly become inaccurate. Soon, more beds or staff are needed in certain locations to meet caseload demand while other locations retain underutilized staff, waiting for additional caseload fluctuations. This type of complexity challenges the best commanders. As in so many other industries, supply and demand principles apply to military health, but very little is stable about military health capacity planning. Planning analysts build complex statistical forecasting models to predict caseload based on historical patterns. These capacity planning techniques work best in stable repeatable processes where caseload and staffing resources remain constant over a long period of time. Variability must be simplified to predict complex operations. This is counterintuitive to the majority of capacity planners who believe more data drives better answers. When the best predictor of future needs is not historical patterns, traditional capacity planning does not work. Rather, simplified estimation techniques coupled with frequent calibration adjustments to account for environmental changes will create the most accurate and most useful capacity planning and management system. The method presented in this article outlines the capacity planning approach used to actively manage hospital staff and space during Operations Iraqi Freedom and Enduring Freedom.

SITUATION

As a planner, you are required to determine how many people, how much space, and how much money you need to meet the projected caseload demand. In the best case, you build out your caseload demand (most likely and worst case), estimate full time equivalents based on established ratios, and secure space, equipment, and funding. Then you execute the plan and hope your estimates are correct. In the worst case, you take any staff, space, and funding you can get and make it work hoping your team never runs out of medical capacity when it is needed most.

As a planner you know many of your planning factors change frequently. Number and type of cases, number of clinical spaces, and availability of types of clinicians and support staff fluctuate in the military medical environment. Maybe you are conservative and usually estimate that you need more staff and more funding to meet the worst-case planning scenario. Perhaps you tend to believe your team can handle large fluctuations in caseload and underestimate the staff, space, and funding needed to meet caseload demand.

Then things change: conflicts arise, war breaks out, natural disasters occur, or other humanitarian support is required. Now you have to plan for a new set of requirements. How do you forecast your needs? How do you know what your actual capacity is with the current staff, space, and funding available to your team given the type of cases you are likely to see?

How do you plan, then manage, your operational capacity efficiently, effectively, and quickly?

PLANNING METHODS FOR COMPLEX OPERATIONS

Current Planning Methods

Planning has come a long way from the days of simplified estimation techniques. Over the last 40 years the operations research and systems analysis (ORSA) community has developed a variety of complex modeling techniques making it possible to accurately predict many planning factors. Planning outcomes account for cumulative variability across the process. Complex computer simulation models must be used to approximate overall system capacity given the variability of the steps within the processes. Input parameters such as processing

times and other planning factors are calculated by developing statistical distributions through highly complex statistical analysis of historical data. These input factors are then used in the simulation to determine a single outcome or set of planning parameters.

This approach can be time consuming, costly, and inflexible to changing environmental factors. Cumulative variability becomes cumulative error when input parameters are changing or unknown. Flexibility, accuracy, and speed are key to wartime capacity planning. When current ORSA planning methods do not meet these requirements, what other methods exist?

Updated Planning Methods for Complex Systems

It appears the planners from many years ago may have had it right: estimation techniques work. Many years before computers, planners used high level measures to estimate staff and space requirements. Today, planning capacity using simplified estimation techniques has proven to be more accurate, more flexible, and less time consuming than newer planning methods. Combining estimation techniques with new insight around behavior of complex systems allows planners to predict and manage operational parameters accurately and quickly. These planning methods work in many different environments and are better suited for wartime planning activities.

This approach to planning focuses on finding key operational driver(s) most closely correlated to the capacity metrics. As drivers change, so do the capacity requirements. This method removes the need to collect extensive data on all processes, staff, and patient caseload. Instead, planners can now focus on monitoring and controlling only a few key factors that will accurately predict capacity. Given that complex systems frequently change, drivers will likely change as well. Continued model calibration and validation is critical when using this simplified planning approach.

Simplified Capacity Planning

The following section outlines the 5 key steps to implementing a simplified capacity planning approach. Examples from Operations Iraqi Freedom and Enduring Freedom are documented below.

1. Understanding the planning request and related metrics.

- What are you trying to predict?
- How much capacity will be available?
- How many staff members are needed?
- How much money is needed?
- How many operating room hours are needed?

2. Determine drivers that predict metrics.

What factors effect what you want to predict?
 What factor or type of case(s) use the greatest quantities of staff and/or space because of volume, time, and intensity?

What type of case(s) have a wide range of volume, time, and intensity requirements?

3. Create predictive algorithm.

$$f(\text{driver}) = \text{predicted metric}$$

$$f(\text{driver}) = \text{driver} \times (a+b)$$

SIMPLE EXAMPLE (1)

Description

The facility needs to manage intensive care unit (ICU) utilization for all wounded, injured, or ill (WII) and has a simple way to measure incoming WII rates.

There are 36 ICU beds and the facility targets an 80% or less utilization to ensure emergency surge capacity in the ICU.

Predicted metric: needed number of ICU beds occupied by WII or ICU

Driver: Mean of WII arriving weekly: $\mu = 12$, $\sigma = 6$

Where: WII weekly mean = $\mu = 12$

WII likely worst case: $\mu + 1\sigma = 12 + (1 \times 6) = 18/\text{week}$

WII today = 10

Note: The factor of $\mu + 1\sigma$ is a good approximation of the “most likely worst case” value, meaning that this capacity requirement will likely occur a few times during a planning season, such as the summer.

Using 1σ is key. Any higher σ factors will plan too many staff, space, and budget requirements for the majority of the operations. Instead, use 1σ to ensure staff is efficiently used and develop a management control dashboard to quickly identify upcoming surges in caseload where operational adjustments may be necessary.

a = mean length of stay in weeks: $\mu = 1.8$ weeks

$b = 0$

$$f(12) = (12 \times 1.8) + 0 = 22$$

$$f(12+6) = (16 \times 1.8) + 0 = 32$$

$$f(10) = (10 \times 1.8) + 0 = 18$$

Outcome: The ICU has capacity for the current rate and the mean rate of WII and will likely begin to run out of capacity under predicted higher demands as displayed in Table 1.

OPERATIONAL SYSTEM CHALLENGES

Table 1. Example 1 Output.

	WII	ICU
	Amputees per Week	Daily Census (mean)
	6	11
	8	14
Today	10	18
Mean	12	22
	14	25
	16	29
Likely worst case	18	32
	20	36

Table 2. Example 2 Output.

	WII	Total ICU Census (WII+non-WII)
	Amputees per Week	Daily Census (mean)
	2	10
	3	12
	5	15
Today	7	18
Mean	9	21
	11	25
Likely worst case	13	28

$$f(9)=(9 \times 1.6)+7=21$$

$$f(9+4)=(13 \times 1.6)+7=28$$

$$f(7)=(7 \times 1.6)+7=18$$

Outcome: The ICU has capacity for the current rate and the average rate of WII and will likely almost run out of capacity multiple times during a planning season as displayed in Table 2.

The recommendation is to divert or postpone non-WII patient care when the average number of amputees begins to increase in preparation of the "likely worst case" levels.

MORE COMPLEX EXAMPLE (2)

Description

The facility needs to manage ICU utilization for all WII but does not have a way to measure incoming WII rates easily. Amputees are more than 50% of the caseload of WII patients because of volume and bed days. Additionally the facility needs to use some of beds for non-WII patients.

There are 36 ICU beds and the facility targets an 80% or less utilization to ensure emergency surge capacity in the ICU.

Predicted metric: needed number of ICU beds occupied by WII or ICU

Driver: Mean of amputees (Amp) arriving weekly: $\mu=9, \sigma=4$

Where: WII weekly mean= $\mu=9$

WII likely worst case=13 per week

WII today=7

a =scaling factor: $\mu=1.6$

Scaling factor considers the length of stay (LOS) for amputees in weeks, LOS for nonamputees, and ratio of WII to amputees.

Note: The scaling factor is most easily developed by taking periodic samples of the key factors including the predicted metric and likely drivers. After collecting multiple samples, develop an equation to determine the scaling factor. If the driver has been accurately identified, this step is easy. If the driver is a combined set of drivers, analytic support will likely be required to perform correlation analysis and develop the scaling factor.

b =mean number of beds used by non-WII: $\mu=7$ beds

NATIONAL CAPITAL REGION EXAMPLE

Table 3 is an example of the model used by JTF National Capital Region Medical during 2010 through 2013 to manage capacity in that region. The red 12 represents the number of amputees arriving on a weekly basis with a moving average of 4 weeks. The model accurately predicted the number of WII in the ICU, medical surgical, and operating rooms on a weekly basis. The model was calibrated for low season and high season fighting twice a year and remained accurate throughout the years.

Table 3. National Capital Region Example.

WII	ICU	Med Surg	OR Hours
Amputees per Week	Daily Census (mean)	Daily WII Census (mean)	WII Hours per Week
2	1	10	48
4	2	19	96
6	3	29	143
8	4	39	191
10	5	49	239
12	5	58	287
14	6	68	335
16	7	78	383
18	8	87	430
20	9	97	478
22	10	107	526
24	11	117	574
26	12	126	622
28	13	136	670
30	14	146	717
32	15	155	765
34	16	165	813
36	16	175	861
38	17	185	909
40	18	194	957

4. Establish reporting and forecasting tools to manage operations.

The examples from step 3 represent one of the many types of management tools that can be developed using this methodology. Thresholds for drivers should be determined and tracked in weekly operational reports. As thresholds are exceeded, action should be taken to adjust available capacity through adding resources and/or adjusting caseload requirements.

5. Track accuracy of algorithm and calibrate as necessary.

It is important to check the accuracy of the algorithm. In the beginning, the accuracy should be validated weekly until the model moves towards steady state. Afterwards, algorithm validation should occur monthly or quarterly to ensure the driver and scaling factor are still correct. Adjustments such as types of cases, number of cases, types of available clinicians, and changes in available space can all change the driver or scaling factor. Validating the algorithm follows the same steps outlined in this article.

APPLICATIONS

The basic approach can be applied to predict many different capacity factors. Some areas studied during 2010 to 2013 include:

- Locations: Walter Reed Army Medical Center, National Naval Medical Center, Fort Belvoir Community Hospital, San Antonio Military Medical Center, San Diego Naval Medical Center, National Intrepid Center of Excellence for Traumatic Brain Injury, and Kimbrough Ambulatory Care Center.

- Areas of Study: WII inpatient and outpatient care, mental health inpatient and outpatient care, rehabilitation staff and space requirements, orthopedic staffing requirements, housing requirements, Wounded Warrior roadmap, and regulation of WII patients to medical facilities.

CONCLUSION

Complex operations can be managed through simple estimation models. It is often no longer necessary to spend excessive amounts of time and money estimating operational capacity if the dynamics of the system do not require it. Several elements of the DOTMLPF* could use this approach: organization, materiel, leadership, personnel, facilities.

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*Doctrine, organization, training, materiel, leadership & education, personnel, facilities



Military Sleep Management: An Operational Imperative

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ABSTRACT

Sleep is critical for military operational readiness but is commonly disregarded during operational planning. The start of combat operations with Operation Iraqi Freedom saw a dramatic rise in diagnosis rates of clinically significant sleep disorders among officers and enlisted. This coincided with a parallel rise in behavioral health disorders. In this article, the etiology of sleep problems and sleep disorders in our military population is reviewed, and guidance is provided for improving sleep health in our military population. It is our view that appropriate sleep planning and management affords military units and commanders a near-term tactical advantage in terms of maintaining alertness, a midterm tactical advantage of decreasing susceptibility to sleep and behavioral health disorders, and a long-term strategic advantage with increased readiness and resiliency of their Soldiers.

Decades of research have demonstrated conclusively that sleep sustains cognitive abilities ranging from simple speed of responding to problem solving, flexible thinking, and the ability to integrate new information into a common mental model.^{1,2} These mental processes underlie successful military operations. Thus, sleep is a vital military resource. However, military operations are usually prolonged, stressful, and take place in austere environments, predisposing Soldiers to insufficient sleep.

Sleep planning and management are force multipliers. In contrast, when sleep is not prioritized and appropriately managed, consequences are not limited to decreased military readiness but also include degraded mental and physical health. Lack of sleep planning and management appears to drive a negative feedback loop in which overall sleep health is degraded by maladaptive sleep habits and practices. The consequences of inadequate sleep planning and management were highlighted in the recent RAND report, *Sleep in the Military*,³ where nearly 50% of military personnel screened positive for disturbed sleep.

Operation Iraqi Freedom, Operation Enduring Freedom, and Operation New Dawn (OIF/OEF/OND) posed unprecedented challenges for sleep management prior to,

during, and after deployment. All branches of the military saw a significant increase in the diagnosis of sleep disorders in the active duty and veteran populations over the course of these operations.⁴ The etiology of these sleep disorders is multifactorial: substandard sleep environments; continuous operations; preexisting poor sleep practices; and perhaps most importantly, the lack of recognition at the individual and organizational level of the importance of maintaining healthy sleep practices.

In this article, we review factors that affect sleep in the deployed setting and their relationship to sleep disorders diagnosed in Soldiers who deployed in support of OIF/OEF/OND. We also describe associations between sleep and behavioral health disorders as well as other comorbidities. We discuss appropriate treatment of sleep disorders in the military population. Our objective is to provide recommendations to improve sleep in future operational environments not only as critical operational enablers but also as preventive measures to reduce the likelihood of Soldiers developing sleep disorders as a consequence of their deployment.

SLEEP PROBLEMS IN THE DEPLOYED ENVIRONMENT

Despite years of anecdotal evidence that deployed military personnel experience sleep problems, it is only recently (within the past 10 years) that deployed Soldiers

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Table 1. Mental Health Advisory Team (MHAT) in-theatre surveys of deployed personnel cited in the text. “J” indicates “joint,” meaning the MHAT survey was administered to more than one branch of military service.

Report Number	Year(s) Conducted	Year Published	Operations	Personnel Surveyed	Documents Available At
V	2007	2008	OIF, OEF	Soldiers	http://armymedicine.mil/Pages/Mental-Health-Advisory-Team-V-Information-.aspx
VI	2008-2009	2009	OIF	Soldiers	http://armymedicine.mil/Pages/Mental-Health-Advisory-Team-VI-Information.aspx
VI	2009	2009	OEF	Soldiers	http://armymedicine.mil/Pages/Mental-Health-Advisory-Team-VI-Information.aspx
VII	2010	2011	OEF	Soldiers, Marines	http://armymedicine.mil/Documents/J_MHAT_7.pdf
VIII	2012	2013	OEF	Soldiers, Marines	http://armymedicine.mil/Documents/J_MHAT_8_OEF_Report.pdf
IX	2013	2013	OEF	Soldiers	http://armymedicine.mil/Documents/MHAT_9_OEF_Report.pdf

were asked about sleep habits and problems as part of the periodic in-theater behavioral health surveys (Mental Health Advisory Team (MHAT)). Sleep may have been ignored because the theoretical model of Soldier well-being that served as the basis for these surveys did not include sleep as a critical factor.⁵ For MHATs 5-9 conducted between 2007 and 2013, military personnel were asked how many hours of sleep they obtained per day, and in a separate item, how many hours of sleep per day they needed in order to feel well-rested.⁶⁻⁹ The response data are presented in Table 1. For MHAT-5, Soldiers reported obtaining an average of 5.6 hours of sleep per day and needing 6.4 hours sleep to feel well rested; substantially below the 7-8 hours amounts established as necessary for maintaining alertness and mental performance.¹⁰ The operational consequences of insufficient sleep are not fully known; however, in MHAT-9,⁸ it was reported that almost 50% of personnel reported they had fallen asleep on a convoy (a monotonous condition under which sleepiness would be unmasked) and 18.4% on guard duty where vigilance is required and could pose risks to the unit as well as the potential for punishment in accordance with Article 113 of the Uniform Code of Military Justice.*

The occurrence of an unintended sleep episode requires a different construct than what is currently viewed as weakness or laziness. Sleep is a biologic requirement. Without adequate sleep, the brain does not function optimally, predisposing Soldiers to becoming a sleep casualty. The consequences of acute insufficient sleep range from minimal (ie, sleeping in a convoy while a passenger) to catastrophic (ie, unavoidably falling asleep while driving a convoy vehicle and causing an accident with loss of life and property). The long-term consequences of insufficient sleep, or chronic casualties, include

*The Uniform Code of Military Justice (UCMJ), a federal law (64 Stat. 109, 10 USC, chap 47), is the judicial code which pertains to members of the United States military. Under the UCMJ, military personnel can be charged, tried, and convicted of a range of crimes, including both common-law crimes (eg, arson) and military-specific crimes (eg, desertion).

cardiovascular disease, hypertension, and obesity.¹¹ The overall effect of insufficient sleep, in both the short and long term, is decreased readiness of the force.

Factors contributing to insufficient sleep in deployed environments were assessed in MHAT surveys conducted in 2010, 2012, and 2013. Consistently, as shown in Figure 1, the 2 factors most frequently reported as interfering with sleep were nighttime duties and poor sleep environment. Specific components of a poor sleep environment that were identified include a lack of adequate noise and light control, suboptimal physical sleep environment (lack of adequate bedding materials and uncontrollable temperature variations) and the use of the sleep quarters for nonsleep activities. For example, nighttime construction projects (to avoid extreme daytime heat) in the vicinity of sleeping quarters were frequently cited as a contributor to a poor sleep environment.¹² Additionally, standard military practice is to assign sleep quarters by rank rather than by shift worked. This results in disrupted sleep, especially for night-shift workers due to lack of noise and light controls. Other behaviors, based on anecdotal reports, which likely contributed to insufficient sleep included communications with family (due to time zone differences, most service members used software applications during their nocturnal sleep period) and computer games; thereby, service members would sacrifice sleep for family obligations and leisure time. Lastly, the deployed setting, which is inherently dangerous, likely plays a role in disrupting sleep as it can cause a hyperaroused state.¹³ Hyperarousal may persist upon redeployment and contribute to the development of insomnia.

In order to compensate for insufficient sleep, Soldiers might use caffeine. In MHAT-7 for example, over 40% of personnel indicated that they used energy drinks, noting that in many units energy drinks were part of the regular unit supply. However, most reported using 2 or fewer per day (the survey did not contain additional questions about consumption of other forms of caffeine

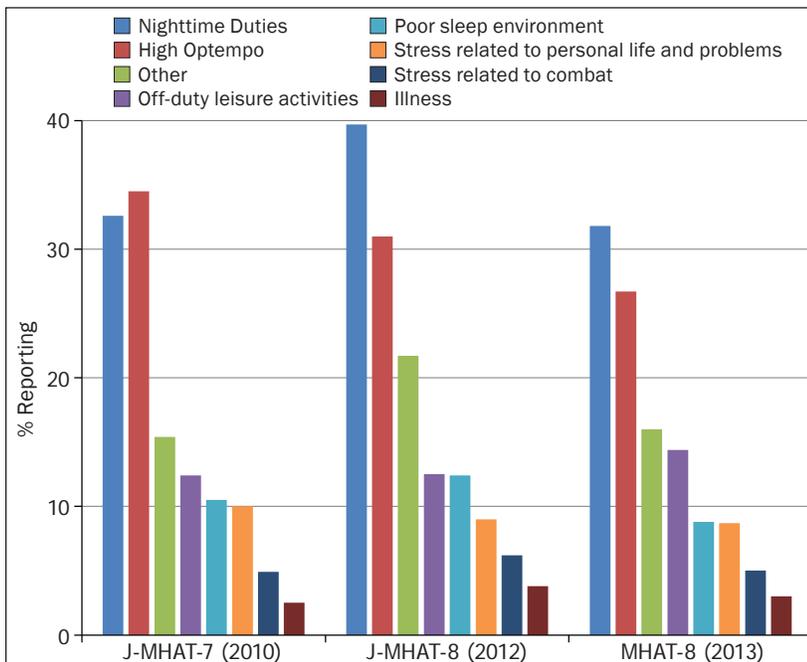


Figure 1. Percentage of respondents reporting sources of sleep disturbance in the deployed environment listed on Mental Health Advisory Team (MHAT) surveys. Results are shown for MHATs conducted in 2010, 2012, and 2013. "J" indicates "joint," meaning the MHAT survey was administered to more than one branch of service.

such as coffee, sodas). Stress related to combat, personal life, and illness were associated with consuming 3 or more energy drinks per day.¹⁴ It is likely that insufficient sleep resulted in higher caffeine use as well as the reports of stress.

In sum, evidence from MHAT surveys indicates that the main sleep problem in-theatre is insufficient sleep driven by night operations and the poor sleep environment. It is probable that what initially constitutes acute sleep problems evolves into a chronic sleep disorder over time. Behavioral factors that developed during deployment such as the inability to maintain consistent sleep routines, hyper-arousal, and caffeine consumption likely contribute to the development of chronic insomnia in some Soldiers.

SLEEP DISORDERS IN MILITARY PERSONNEL

For a variety of reasons including increased awareness of sleep disorders and enhanced sleep medicine services, the number of sleep study procedures and personnel tested for sleep disorders increased from 2003 through 2013. Concurrently and for the first time in modern warfare, Soldiers with diagnosed obstructive sleep apnea (OSA) were allowed to deploy and their continuous positive airway pressure (CPAP) treatment was safely and successfully managed in-theater. The latter substantially increased the number of deployable

personnel. In contrast, difficulties sleeping (both acute and chronic) in Soldiers proved challenging to manage in theater and following redeployment. A common feature of most sleep disorders is that they reduce total recuperative sleep time, thus degrading waking function, operational readiness, and quality of life. Successfully managing other sleep disorders would increase the readiness of the force.

Insomnia

Insomnia is characterized by difficulties falling asleep and/or staying asleep that persist for at least 3 months.¹⁵ During OIF/OEF/OND, diagnosis rates of insomnia increased dramatically in all military service branches.¹⁶ In the Army, rates increased from less than 3.6 per 10,000 person-years in 1998 to almost 432 per 10,000 person-years in 2012. Insomnia is currently the most common sleep-related complaint among military personnel.¹⁷ Results from several studies demonstrated that insomnia which develops during active service is often resistant to pharmacotherapy and co-

morbid with other conditions, notably behavioral health disorders and traumatic brain injury.^{18,19} Sedative hypnotics were the most commonly prescribed treatment for sleep disturbances in theater, with up to 11.4% of military personnel reporting they had taken medication for a sleep problem.⁸

While sedative hypnotics are often prescribed for the treatment of insomnia, cognitive behavioral therapy for insomnia (CBTi) consisting of sleep restriction and stimulus control administered by behavioral sleep medicine specialists is recognized as the standard of care.²⁰ These techniques train the individual on sleep-promoting practices and avoid the side effects of sedative hypnotics. Results from clinical trials have shown that CBTi is superior to prescription sleep medications and can be completed successfully in 4-12 weeks.²¹ Evidence is accumulating that CBTi is effective for improving sleep in veterans.²² Further research is required to determine if CBTi is equally efficacious in active duty personnel in garrison and operational environments when administered remotely.

Obstructive Sleep Apnea

Obstructive sleep apnea is characterized by repetitive collapse of the upper airway during sleep, resulting in disrupted breathing that lowers oxygen levels and causes brief awakenings that contribute to daytime sleepiness.

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Table 2. Symptoms/comorbidities, preferred modes of treatment, and operational considerations regarding the most common sleep disorders in active duty personnel.

Disorder	Symptoms/Comorbidities	Treatment	Operational Considerations
Chronic severe insufficient sleep (not due to underlying sleep or other disorder)	Sleepiness during waking period. Attention lapses/degraded mental performance. Irritability, negative mood.	Increase sleep to 7-8 hours per 24 hours via increased nightly time in bed, naps, etc. If due to poor sleep environment, institute light/sound/temperature controls.	Until sufficient sleep is restored, Soldier waking performance will remain impaired although subjective alertness may improve. Systemic problems related to poor sleep environment must be addressed at the appropriate echelon of command.
Insomnia	Difficulty falling asleep. Difficulty staying asleep. Hyperarousal/rumination/racing thoughts. Sleepiness during waking period.	Cognitive behavioral therapy (CBTi) administered by trained professional (can be accomplished remotely via telephone). Short-term (<4 weeks) use of nonbenzodiazepine hypnotic under healthcare provider supervision.	CBTi may take up to 6 weeks to show efficacy; during that time, Soldier waking performance may be impaired. Soldier should relinquish weapon while using hypnotics. If symptoms which impair duty performance do not improve after 4 weeks, Soldier should be evacuated to definitive care.
Obstructive sleep apnea (OSA)	Extreme sleepiness during waking period. Gasping during sleep. Loud snoring (not always present).	Continuous positive airway pressure is standard therapy. Mandibular advancement devices for treating mild OSA. Prescription stimulants to treat residual sleepiness are not recommended.	Mild asymptomatic OSA (with or without CPAP) does not require a waiver to deploy. Any degree of symptomatic OSA requires evaluation and waiver for deployment. Moderate and Severe OSA require evaluation to document CPAP effectiveness, resolution of symptoms, adherence/compliance prior to issuance of waiver for deployment. Other forms of sleep apnea (eg, complex sleep apnea and central sleep apnea) are nondeployable. Mandibular advancement devices as adjunct or potential replacement for CPAP in moderate and severe in deployment requires study.
Parasomnias	Walking during sleep. Nightmares. Trauma Associated Sleep Disorder.	Ensure 7-8 hours sleep per 24 to rule out insufficient sleep as cause. Safe sleeping environment without access to weapons, locked door. Assess for other comorbid disorders to include post-traumatic stress disorder.	Parasomnias pose a safety concern anywhere weapons are in close proximity to sleeping quarters. Service members with documented parasomnias should be removed from deployed setting and referred for appropriate specialty evaluation. Because adequate sleep cannot be ensured during deployment, documentation of such an episode should be a discriminator for operational assignments.

Untreated OSA not only negatively affects the patient, but the patient's loud snoring can disrupt sleep in those sleeping nearby. Notably, moderate and severe OSA which are not adequately treated can limit a service member's ability to deploy.²³ It is common in the general population, but prevalence is higher among males, obese patients (body mass index greater than 30), and those with posttraumatic stress disorder and/or traumatic brain injury (TBI).²⁴ The standard therapy for OSA is CPAP, although mandibular advancement devices are effective in mild cases. Military personnel who adhere to CPAP show improved alertness and sleep quality.²⁵

Parasomnias

Parasomnias are unwanted complex behaviors occurring during sleep. In Soldiers, these nocturnal behaviors typically arise from slow-wave sleep (which increases with insufficient sleep). Sleepwalking is common in children but usually abates in adolescence. Sleep walking that persists beyond adolescence is considered

pathologic, and it places the afflicted Soldier at risk of unintended self-injury. During OIF/OED/OND, there were increased clinical reports of this disorder, which is likely linked to insufficient sleep.²⁶ Other factors that can exacerbate sleepwalking include sedative medications and undiagnosed OSA. The primary treatments are ensuring adequate sleep duration and a safe sleeping environment (Table 2).

SLEEP DISORDERS AND SLEEP INSUFFICIENCY

The most common sleep disorders in the military (summarized above) are characterized by insufficient recuperative sleep and decreased readiness. Chronic insufficient sleep is consistently reported by deployed personnel. This can precipitate parasomnias, contribute to conditioned arousal associated with insomnia, and potentially exacerbate sleep disordered breathing. Further, sleep disorders are comorbid with numerous other behavioral health problems, and evidence suggests that failure to treat the sleep disorder reduces the efficacy of

treatment aimed at the behavioral health issue (Figure 2). Appropriate sleep planning and treatment of sleep disorders in the deployed and nondeployed setting are required to maximize military medical readiness.

ANALYSIS AND RECOMMENDATIONS

Insufficient sleep poses a direct threat to military readiness and Soldier health. In order to implement the changes for military appropriate sleep practices and sleep health, the Department of Defense (DoD) and Department of the Army must have guidance on this topic. In the US Central Command personnel policy for deployment fitness standards, sleep deprivation and sleep disturbance are listed as environmental extremes and that "...if maintaining an individual's health requires avoidance of these extremes or conditions, she/he should not deploy..."²³ Although some sleep deprivation and disturbance are at times unavoidable, results from MHAT reports and other studies suggest insufficient sleep is in part preventable, notably that which is caused by lack of sleep planning and the poor sleep environment.

Solution 1: DoD Policy Guidance on Military Appropriate Sleep Practices are Required

Throughout the DoD there currently are appropriate policies, awareness, and management of TBI. This occurred as a direct result of *DoD Instruction 6490.11*.²⁷ Similar expert guidance issued by the DoD would ensure that that all military branches develop organizational changes to manage sleep.

Solution 2: Recategorize Sleep Management within the Army Universal Task List

Sleep management is viewed as a commander's responsibility. Within the *Army Universal Task List*²⁸ unit sleep plans are listed in Chapter 5 (Conduct Mission

Command), Section II, ART 5.2.3 Execute Sleep Plans. It should be noted that *Field Manual 6-22.5* cited in ART 5.2.3 is now obsolete, superseded by *Army Techniques Publication 6-22.5*,²⁹ (*ATP 6-22.5*) in which Chapter 2, Section 1 provides guidance in sleep management, sleep environment, and sleep loss. There appears to be no specific requirement for a sleep management plan in the Mission Essential Task List (METL), and whether sleep plans are routinely included in METLs is unknown. We suggest that sleep planning be recategorized within the *Army Universal Task List* as a logistical function (Chapter 4, Section I (Provide Logistical Support)^{28(p4-2)} identical to planning for sufficient food, water, etc.

Solution 3: Unit Level Sleep Trainers

To ensure the guidance contained in *ATP 6-22.5*, is understood and considered in training and operational planning, the Army needs Soldiers specifically trained in sleep education, planning, and management who are tasked with providing guidance to commands and developing the unit sleep plan. These Soldiers would serve as resources to the commander for implementing changes required for a military appropriate sleep practice. The other aspect is training Soldiers on appropriate sleep practices, such as sleep discipline. The inherent stress of working in the military with shift changes, 24-hour duty, and frequent moves makes developing a sleep practice difficult. Similar to the master fitness trainer who teaches Soldiers how to perform physical training, a sleep trainer is required to provide the same level of education to help Soldiers develop their military appropriate sleep practice. In addition, focused education regarding sleep planning and management should be incorporated into military professional development courses, including the Officer Basic Course, Captain's Career Course, and the Advanced Noncommissioned Officer Course.

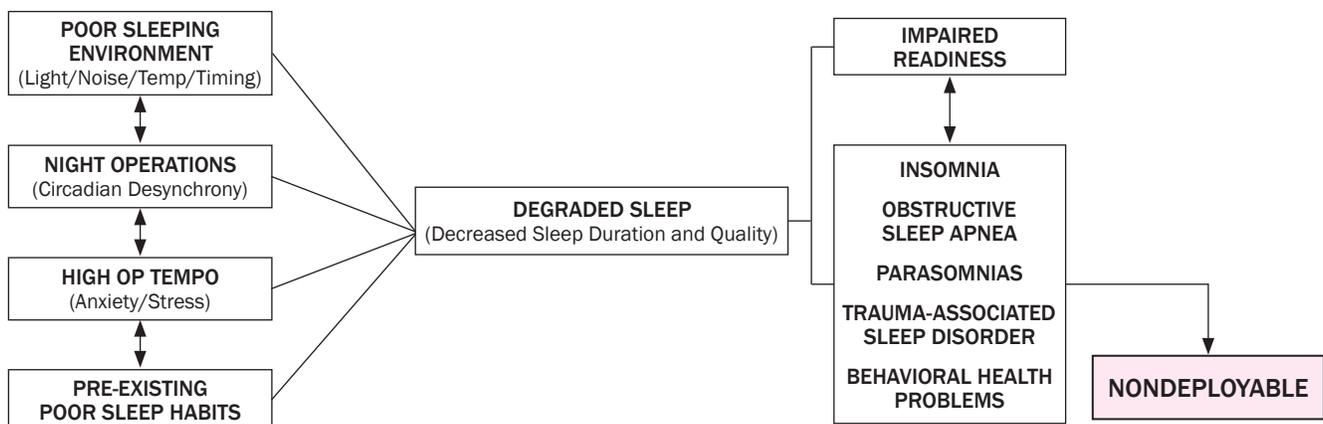


Figure 2. Model demonstrating how lack of sleep planning and management decreases readiness and deployability of Soldiers.

CONCLUSION

While periods of insufficient sleep are unavoidable during sustained operations, proper planning ensures adequate recovery sleep and minimize sleep casualties. Embedding sleep education and management in the military will (1) help Soldiers develop appropriate sleep practices in garrison, (2) improve sleep during deployment and thus directly improve operational readiness, and (3) reduce the likelihood of Soldiers developing sleep and behavioral health disorders while deployed, thus improving the health of the force and reducing overall healthcare costs to the military.

REFERENCES

1. Dinges DF, Pack F, Williams K, et al. Cumulative sleepiness, mood disturbance and psychomotor vigilance performance decrements during a week of sleep restricted to 4-5 hours per night. *Sleep*. 1997;20(4):267-277.
2. Van Dongen HP, Maislin G, Mullington JM, Dinges DF. The cumulative cost of additional wakefulness: dose-response effects on neurobehavioral functions and sleep physiology from chronic sleep restriction and total sleep deprivation. *Sleep*. 2003;26: 117-129.
3. Troxel WM, Shih RA, Pedersen ER, et al. *Sleep in the Military*. Santa Monica, CA: RAND Corporation; 2015. Report RR-739-OSD. Available at: http://www.rand.org/pubs/research_reports/RR739.html. Accessed March 9, 2016.
4. Armed Forces Health Surveillance Center. Insomnia, active component, U.S. armed forces, January 2000-December 2009. *MSMR*. 2010;17(5):12-15.
5. Bliese PD, Castro CA. The soldier adaptation model (SAM): applications to peacekeeping research. In: Britt TW, Adler, AB, eds. *Psychology of the Peacekeeper: Lessons from the Field*. Westport, CT: Praeger Publishers; 2003:185-203.
6. *Mental Health Advisory Team (MHAT) V: Operation Iraqi Freedom 06-08, Iraq; Operation Enduring Freedom 8, Afghanistan*. Washington, DC: Office of The Surgeon General, US Dept of the Army; February 14, 2008.
7. *Joint mental health advisory team 7 (J-MHAT 7) Operation Iraqi Freedom 2010*. Washington, DC: Office of The Surgeon General, US Dept of the Army; February 22, 2011. Available at: http://armymedicine.mil/Documents/J_MHAT_7.pdf. Accessed March 8, 2016.
8. *Mental Health Advisory Team 9 (MHAT 9) Operation Enduring Freedom (OEF) 2013 Afghanistan*. Office of The Surgeon General, US Dept of the Army; October 10, 2013.
9. *Operation Iraqi Freedom (OIF) Mental Health Advisory Team (MHAT) Report*. Washington, DC: Office of The Surgeon General; Headquarters, Department of the Army, G-1; 2003. Available at: <http://www-tc.pbs.org/wgbh/pages/frontline/shows/heart/readings/mhat.pdf>. Accessed September 11, 2008.
10. Consensus Conference Panel. Joint Consensus Statement of the American Academy of Sleep Medicine and Sleep Research Society on the Recommended Amount of Sleep for a Healthy Adult: Methodology and Discussion. *Sleep*. 2015;38:1161-1183.
11. Ferrie JE, Shipley MJ, Cappuccio FP, et al. A prospective study of change in sleep duration: associations with mortality in the Whitehall II cohort. *Sleep*. 2007;30:1659-1666.
12. Peterson AL, Goodie JL, Satterfield WA, Brim WL. Sleep disturbance during military deployment. *Mil Med*. 2008;173(3):230-235.
13. Bonnet MH, Arand DL. Hyperarousal and insomnia: state of the science. *Sleep Med Rev*. 2010;14(1):9-15.
14. Centers for Disease Control and Prevention. Energy drink consumption and its association with sleep problems among U.S. service members on a combat deployment-Afghanistan, 2010. *MMWR Morb Mortal Wkly Rep*. 2012;61:895-898.
15. *International Classification of Sleep Disorders—Third Edition (ICSD-3)*. Darien, IL: American Academy of Sleep Medicine; 2014.
16. Armed Forces Health Surveillance Center. Risk of Type II Diabetes and Hypertension Associated with Chronic Insomnia Among Active Component, U.S. Armed Forces, 1998-2013. *MSMR*. 2014;21:613.
17. Mysliwicz V, Gill J, Lee H, et al. Sleep disorders in US military personnel: a high rate of comorbid insomnia and obstructive sleep apnea. *Chest*. 2013;144(2):549-557.
18. Mysliwicz V, Roth B. Pharmacotherapy refractory insomnia in soldiers with traumatic brain injury. *Chest*. 2013;143(2):582-583.
19. Bramoweth AD, Germain A. Deployment-related insomnia in military personnel and veterans. *Curr Psychiatry Rep*. 2013;15:1-8.
20. Jacobs GD, Pace-Schott EF, Stickgold R, Otto MW. Cognitive behavior therapy and pharmacotherapy for insomnia: a randomized controlled trial and direct comparison. *Arch Intern Med*. 2004;164(17):1888-1896.
21. Sivertsen B, Omvik S, Pallesen S, et al. Cognitive behavioral therapy vs zopiclone for treatment of chronic primary insomnia in older adults: a randomized controlled trial. *JAMA*. 2006;295(24):2851-2858.

22. Germain A, Richardson R, Stocker R, et al. Treatment for insomnia in combat-exposed OEF/OIF/OND military veterans: preliminary randomized controlled trial. *Behav Res Ther.* 2014;61:78-88.
23. US Central Command. PPG-Tab A: Amplification of the Minimal Standards of Fitness for Deployment to the CENTCOM AOR; To Accompany MOD Twelve To USCENTCOM Individual Protection And Individual/Unit Deployment Policy. No document date. Available at: <http://cpol.army.mil/library/mobil/MOD12-TabA.pdf>. Accessed March 9, 2016.
24. Collen J, Orr N, Lettieri CJ, Carter K, Holley AB. Sleep disturbances among soldiers with combat-related traumatic brain injury. *Chest.* 2012;142(3):622-630.
25. Mysliwec V, Capaldi VF 2nd, Gill J, Baxter T, O'Reilly BM, Matsangas P, Roth BJ. Adherence to positive airway pressure therapy in U.S. military personnel with sleep apnea improves sleepiness, sleep quality, and depressive symptoms. *Mil Med.* 2015;180(4):475-482.
26. Joncas S, Zadra A, Paquet J, Montplaisir J. The value of sleep deprivation as a diagnostic tool in adult sleepwalkers. *Neurology.* 2002;58(6):936-940.
27. *Department of Defense Instruction 6490.11: DoD Policy Guidance for Management of Mild Traumatic Brain Injury/Concussion in the Deployed Setting.* Washington, DC: US Dept of Defense; September 2012. Available at: <http://www.dtic.mil/whs/directives/corres/pdf/649011p.pdf>. Accessed March 9, 2016.
28. *Army Doctrine Reference Publication 1-03: The Army Universal Task List.* Washington DC: US Dept of the Army; October 2015. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/adrp1_03.pdf. Accessed March 9, 2016.
29. *Army Techniques Publication 6-22.5: A Leader's Guide to Soldier Health and Fitness.* Washington, DC: US Dept of the Army; February 2006:2-1. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/atp6_22x5.pdf. Accessed March 9, 2016.

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Evolution of Military Combat Eye Protection

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ABSTRACT

Appreciation for combat eye protection steadily increased following World War II. Products derived from experiences in World War I, World War II, Korea, Vietnam, and the Iran/Iraq war drove technical improvements throughout the 1980s and 1990s. Dismal wear compliance prior to 2004 indicates Soldiers and their leaders did not appreciate these improvements and found little value in the bulky, ugly, and uncomfortable products. In 2003, the 10th Mountain Division requested enhanced eye protection. Program Executive Office Soldier, the optometry consultant to the Army Surgeon General, members of the Tri-Service Vision Conservation and Readiness Program, and other subject matter experts selected and tested commercial off-the-shelf eye protection against military ballistic impact standards. Optical devices that met ballistic standards formed the first Authorized Protective Eyewear List and were fielded beginning in 2004. Wear compliance rose dramatically for the stylish protective eyewear, reaching 85% to 95% and eye injuries decreased across the Department of Defense even as the incidence of attacks in Iraq increased. Researchers continue to evaluate new materials and designs to increase the capabilities, features and level of protection of future ballistic eyewear.

HISTORY

Routine Army-issued eye protection began during World War II for certain specialties and steadily progressed over the past 60 years into the current Military Combat Eye Protection (MCEP) program. The most significant progress and positive impact occurred beginning in 2003 despite the lack of applied technological breakthroughs in protective eyewear materials. The dramatic improvement was largely due to style and comfort which drove wear compliance rates up across the military services. This article provides only a brief historical review of the MCEP program. A thorough history of combat eye protection can be found elsewhere.^{1,2} Products derived from experiences in World War I, World War II, Korea, Vietnam and the Iran/Iraq war drove many technical eye protection improvements. Beginning in 1962, the Army began researching materials, ballistics, and human performance factors which led to the concept of a ballistic spectacle.¹ In 1983, the Army replaced the acetate shield in the M-1944 Sun, Wind and Dust goggle with polycarbonate and added laser protection in 1990. The Army also developed the Ballistic Laser Protective System (BLPS) and began limited procurement in 1989. The BLPS optical devices supported a prescription insert. The requirements for the Special Protective Eyewear Cylindrical System (SPECS) were not formalized until 1984, 22 years after the initial concept, and the product did not become standard issue until 1995. SPECS optical devices did not support a prescription insert. Soldiers rejected BLPS and SPECS, and the force protection improvements were largely lost on the force prior to 2004 due to poor wear compliance.³ These devices were ugly, bulky, and uncomfortable, but they worked.

In 2003, the 10th Mountain Division submitted an urgent request for enhanced eye protection. Prior to 2004, Soldiers largely deployed with limited ballistic eyewear and typically wore commercial sunglasses, goggles or tinted prescription spectacles issued by the Army. Decision makers were keenly aware of the 11 year SPECS effort to deliver an unpopular and rarely worn Army-designed ballistic spectacle manufactured under contract. Representatives in Program Executive Office (PEO) Soldier, the optometry consultant to the Army Surgeon General, members of the Tri-Service Vision Conservation and Readiness Program (TSVCRP) and various other subject matter experts were not interested in repeating the SPECS experience. Instead, these leaders evaluated commercially available eye protection against military ballistic standards. Optical devices that met the standards were authorized for wear beginning July 8, 2003. These products included clear and tinted lenses, cleaning cloths, and carrying cases.⁴ These devices formed the first Authorized Protective Eyewear List (APEL) in 2004 and were issued to Soldiers through the Rapid Fielding Initiative mechanism. By the end of 2004, every deployed or deploying Soldier had an APEL-approved MCEP device, and soon thereafter Soldiers began to receive MCEP devices upon accession.

EFFICACY

MCEP devices clearly protect the wearer and prevent eye injuries, but they are not designed to stop a bullet or protect the wearer just 3 meters from a massive blast.⁵ MCEP devices protect the wearer from fragments and minor blunt force and have been extremely effective in this capacity for decades. A 1982 study on eye injuries

during the Lebanon War found not a single eye injury occurred to Soldiers who had ballistic eye protection properly placed over the eyes at the time of injury.⁶

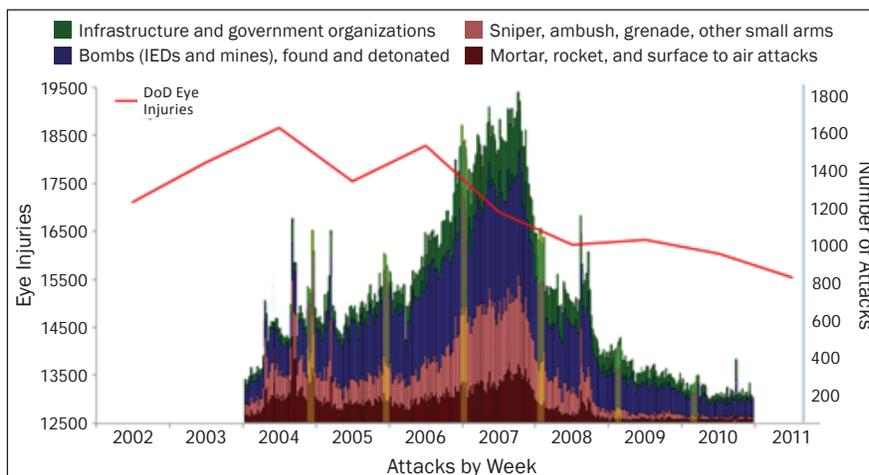
A 2005 study on injuries suffered by Marines performing a convoy security mission found that the Marines suffered 188 injuries in 32 attacks over 6 months. Upper extremities suffered 22% of the injuries and 53% were head injuries. Despite these large numbers, the Marine unit suffered only one eye injury (0.5%). This low eye injury rate is remarkable when you consider 75% of the injuries were to the upper body and head. The authors attribute this remarkably

low eye injury rate to the “nearly 100% conformity to... ballistic eye protection” use.⁷ The authors also noted a number of patients presented with shrapnel and debris damage to their protective eyewear which implies the devices prevented ocular injuries.

A British study from 2011 reviewed hospital records of medically evacuated British service members as well as postmortem reports of all British service members killed in action or who died of wounds during active service. The authors mapped all the facial wounds and concluded that combat eye protection “...could have prevented 7 deaths and visors 19 deaths” had the service members worn them.⁸

In 2013, another British study reviewed all the injuries treated at Camp Bastion (Afghanistan) due to improvised explosive devices (IEDs). The authors compared the incidence of eye injuries between International Security Assistance Force (ISAF) Soldiers who were equipped with eye protection and Afghan National Security Force (ANSF) Soldiers who were not. There were 41 injured ISAF patients with three total eye injuries compared to 53 injured ANSF patients with 24 total eye injuries.⁹ Clearly eye protection reduces the incidence of eye injuries.

The modern MCEP program began fielding APEL products in 2004. The Department of Defense realized a near-immediate reduction in eye injuries. Injuries began to increase again between 2005 and 2006 and then steadily declined. The remarkable effect of MCEP in the reduction of eye injuries despite the 2006-2007 increase in frequency of attacks is demonstrated in the Figure.



MCEP Effectiveness: Eye injuries vs frequency of attacks in Iraq, 2002-2011. DoD eye injury data provided by the Armed Forces Health Surveillance Center. Data for frequency of attacks from DoD Report to Congress, June 2010.¹⁰

COMPLIANCE

Style remains the most significant modern MCEP wear compliance driver. MCEP style achieved user buy-in faster and better than education or mandates from leaders. Service members wanted to wear APEL devices because they looked good. Education efforts attempted to convince troops to wear MCEP based on the force protection benefit, but most of the convincing was already done through style. Prior to the APEL, service members and units could order and use BLPS and SPECS, which met the same ballistic protection standards of current APEL products. Users rejected BLPS/SPECS because they were ugly, uncomfortable, and bulky. Mechanized and motorized units still used the M1944 Sun, Wind and Dust goggle, but training habits resulted in their use only when on the move in unprotected conditions such as traveling in an open hatch. Nonmechanized units deployed with sunglasses and ski goggles that carried virtually no capacity to protect the wearer from explosive fragments. Infantry forces and those performing Infantry tasks were the most vulnerable to eye injuries from IEDs and enemy attacks.

MCEP wear compliance rates are difficult to measure, so assessment largely depends on documented wear at the time of injury, survey results, and other forms of analysis. Compliance also appears to vary based on unit policy, leader direction or example, duty location, and perceived threat. Eye protection use at the time of injury is poorly documented. Frequently patients cannot remember if they were wearing eye protection at the time of injury and “...recording of eye protection is not the first responder’s...priority.”¹¹ Reports include wear compliance rates of just over 9%, 14%, 28.9%, and 41%

at the time of injury.^{4,10,12,13} Weichel found 24% of OIF/OEF related eye trauma cases evacuated to Walter Reed Army Medical Center between October 2001 and September 2006 were documented to have been wearing MCEP at the time of injury.¹⁴ Thirty-four percent were documented without MCEP use at the time of injury, and 41% lacked MCEP wear documentation. Gondusky reported “near 100% wear compliance” in the Marine unit he studied.⁷

COL (Ret) David Hilber conducted 3 Army-wide MCEP surveys in 2008, 2010, and 2011 while assigned to the Tri-Service Vision Conservation and Readiness Program, Army Public Health Command.* The 2008 survey received 4900 responses and indicated 78% of Soldiers reported MCEP was mandatory during deployment and 65% reported MCEP use was mandatory on home station weapons ranges. Eighty-six percent of respondents deployed to OIF/OEF wore MCEP on convoys and missions outside forward operating bases and 54% wore MCEP anytime they were outdoors while deployed. Sixty-seven percent reported using MCEP during training, 35% reported using MCEP while performing maintenance, and 20% reporting using MCEP at home. In 2008, the Army issued an All Army Activities message* to boost wear compliance and remind Soldiers to wear only APEL-approved devices. The results of Dr Hilber’s surveys in 2010 and 2011 indicated Soldier wear compliance while deployed rose to 84% in 2010 and to 95% in 2011.

LTC Jose Capo-Aponte and researchers at the Army Aeromedical Research Laboratory analyzed photos of deployed Soldiers outside forward operating bases from 2002 through 2010 and determined the percentage of random, observable MCEP wear increased from approximately 20% to 95% over that time period (unpublished data).

THREAT/PROTECTION MISMATCH

Following Operation Desert Storm, the Army reviewed and updated ballistic impact standards. In 1996, the Army published updated performance specifications for the SPECS devices. The fragmentation standard remains today and applies to APEL products.^{15,16} The current ballistic standard requires eye protection to withstand the impact from a .15 caliber, 5.7 grain, T37 shaped (non-spherical) projectile traveling between 640 and 660 feet per second. This standard is based on experiences and assumptions from previous conflicts as well as protective material and cost limitations. Ballistic test methods for armor published on December 18, 1997, updated the previous 10-year old standard.¹⁷

* Internal military documents not readily accessible by the general public.

The threat from IEDs influenced force protection design and materials across many systems over the past decade, but has not yet prompted increased eye protection standards. There are too many variables involved for a precise threat/protection comparison, but a general comparison is quite easy. The fragments from an IED built with a 155 mm artillery shell have an initial velocity between 1,200 and 1,800 meters per second.¹⁸ The fragments are highly variable in size, but assuming there are fragments roughly similar to the standard T37 shaped, 5.7 grain, .15 caliber projectile, the initial velocity of IED fragments carry anywhere from 6 to 9 times greater energy than the current eye protection ballistic standard.

There is a physical limit for spectacle and goggle based eye protection above which additional protection is pointless. The current MCEP standard is well below that physical limit and should be increased to provide improved protection. The current standard relies heavily on material properties of polycarbonate, a soft but strong material capable of absorbing tremendous impact without fracturing. Newer materials such as polyamides (Trivex, Trogamid) outperform polycarbonate in ballistic tests.¹⁹ These materials are generally lighter and stronger than polycarbonate, but manufacturing challenges, cost, and the existing standard prevent the market from offering improved eye protection with these materials. Other options include aluminum oxynitride (ALON), a ceramic frequently described as “transparent aluminum.”²⁰

A revolutionary material may provide much more than just increased protection. Graphene is a recently discovered material with incredible physical properties.²¹ Graphene is 200 times stronger than steel by weight, it conducts electricity, is transparent, flexible, and self-healing. Protective goggles with a thin graphene film could theoretically charge a battery and provide a heads up display or quickly switch between clear and electrically tinted while providing dramatically increased ballistic protection.

BRANDING

Proper branding attracts users and improper branding repels them. When the APEL first came out, the proponent wanted to put the Army Strong star logo on each product. Subject matter experts and TSVCRP members challenged this effort and successfully overturned it. The final products carry a nonparochial “APEL” marking to avoid repelling non-Army personnel. Navy, Air Force, and Marine personnel would not want to wear equipment with an Army logo on it and no one wanted to see a service member injured because he or she refused

to wear eye protection due to the logo. All services use some variation of the products on the APEL. This is an important lesson when developing joint products.

LOGISTICAL EFFICIENCY

For the first decade, each APEL-approved MCEP device that supported a prescription lens carrier required a unique insert specific to the product's manufacturer. This created a logistical burden for Soldiers, leaders, clinicians, and the ophthalmic labs that generated prescription spectacle inserts. In 2015, the Universal Prescription Lens Carrier (UPLC) became the standard insert with the release of the March 2015 APEL. The UPLC replaced 8 unique APEL inserts, greatly simplifying the logistical support. More importantly, the UPLC empowers the end user to change APEL products without adding a burden to the optometry team, clinic, or ophthalmic production system by ordering a unique spectacle insert for the new APEL item. The UPLC only works with APEL products and does not extend to various chemical protective masks currently in use. Protective mask manufacturers may design and field an adaptor for future use.

EXCESSIVE CHOICE

The March 2015 APEL consists of 31 options. There are 16 spectacle choices and 15 goggle choices. Seven spectacles and 10 goggles support a prescription lens carrier. The current large APEL selection is the result of contracting rules, not an Army desire for extensive choice. The Army predominantly uses 3 spectacle varieties and 4 goggles. An APEL of seven to twelve options is required to meet the fit and function requirements of a very diverse force. One size does not fit all and the Services should resist the temptation to simplify and standardize protective eyewear down to just one or two choices. The importance of proper fit for every user outweighs the convenience and aesthetic appeal of an artificially limited product line.

DOTMLPF* APPLICATION

The MCEP program is primarily a materiel function and secondarily a training function. The materiel function should be addressed by updating the protective standards through collaboration among the Army Public Health Center (Provisional), Army Medical Command, PEO-Soldier, Natick Research Development and Engineering Center, Research Development and Engineering (RDE) Command and industry. Advances in applied materials and technology should be coordinated with PEO-Soldier, RDE Command, and the Defense Advanced Research Projects Agency. The training function should be addressed by uniform requirements

* Doctrine, organization, training, materiel, leadership & education, personnel, facilities.

to wear eye protection during training. Survey results from 2008, 2010, and 2011 revealed inconsistent force protection policy and/or enforcement which may result in preventable injuries.

CONCLUSION

The effectiveness of Military Combat Eye Protection has increased over the past decade due to vastly improved wear compliance. Military leaders recognized the eye injury threat and strongly supported this force protection element. Through that process, the subject matter experts appreciated the power of style and comfort on user acceptance and deliberately sought those features in products that met military ballistic impact standards. Policy, branding, and universal components matured over the past 10 years to improve awareness, choice, and efficiency. The decades-old technology of polycarbonate lenses still provides effective protection from fragments and small projectiles, but newer materials may provide improved protection with less weight. The existing ballistic protection standards should be reviewed and likely increased to better address the threat of eye injuries from improved explosive devices. Future advances with recently discovered materials may dramatically expand the functionality of protective eyewear with integrated digital overlays and electronically controlled tints, while increasing or maintaining the required level of protection.

REFERENCES

1. LaPiana FG, Ward TP. The development of eye armor for the American infantryman. *Ophthalmol Clin North Am.* 1999;12:421-434.
2. Ari AB. Eye injuries on the battlefields of Iraq and Afghanistan: public health implications. *Optometry.* 2006;7:329-339.
3. Heier JS, Enzenauer RW, Wintermeyer SF, Delaney M, LaPiana FP. Ocular injuries and diseases at a combat support hospital in support of Operations Desert Shield and Desert Storm. *Arch Ophthalmol.* 1993;111:795-798.
4. US Department of the Army. Memorandum; Subject: Authorization to Requisition and Use Commercial Eyewear as Alternatives to the Sun, Wind and Dust (SWDG) for Non-Laser Missions and Training Scenarios. Washington DC: US Dept of the Army, Program Manager Soldier Equipment; July 8, 2003.
5. Mader TH, Carroll RD, Slade CS, George RK, Ritchey JP, Neville SP. Ocular war injuries of the Iraqi insurgency, January-September 2004. *Ophthalmology.* 2006;113:97-104.
6. Belkin M, Treister G, Dolan S. Eye injuries and ocular protection in the Lebanon War, 1982. *Isr J Med Sci.* 1984;20:333-338.

THE ARMY MEDICAL DEPARTMENT JOURNAL

7. Gondusky JS, Reiter MP. Protecting military convoys in Iraq: An examination of battle injuries sustained by a mechanized battalion during Operation Iraqi Freedom II. *Mil Med*. 2005;170:546-549.
8. Breeze J, Allanson-Bailey LS, Hunt NC, et al. Surface wound mapping of battlefield occulo-facial injury. *Injury*. 2011;43(11):1854-1860.
9. Parker P, Mossadegh S, McCrory C. A comparison of the IED-related eye injury rate in ANSF and ISAF forces at the UK R3 Hospital, Camp Bastion, 2013. *J R Army Med Corps*. 2015;160:73-74.
10. US Department of Defense. *Measuring Stability and Security in Iraq, Report to Congress, June 2010*. Washington, DC: US Dept of Defense; 2010:27. Available at: http://www.defense.gov/Portals/1/Documents/pubs/June_9204_Sec_Def_signed_20_Aug_2010.pdf. Accessed March 11, 2016.
11. Vlasov A, Ryan DS, Ludlow S, Weichel ED, Colyer MH. Causes of combat ocular trauma-related blindness from Operation Iraqi Freedom and Enduring Freedom. *J Trauma Acute Care Surg*. 2015;79(4 suppl 2):S210-S215.
12. Thach AB, Johnson AJ, Carroll RB, et al. Severe eye injuries in the war in Iraq, 2003-2005. *Ophthalmology*. 2008;115(2):377-382.
13. Thomas R, McManus JG, Johnson A, Mayer P, Wade C, Holcomb JB. Ocular injury reduction from ocular protection use in current combat operations. *J Trauma*. 2009;66(suppl 4):S99-S103.
14. Weichel, ED, Colyer MH, Ludlow SE, Bower KS, Eiseman AS. Combat ocular trauma visual outcomes during operations Iraqi Freedom and Enduring Freedom. *Ophthalmology*. 2008;115(12):2235-2245.
15. Defense Logistics Agency. *Performance Specification: Spectacles, Special Protective Eyewear Cylindrical System (SPECs)*. Washington, DC: US Dept of Defense; April 25, 1996. MIL-PRF-31013.
16. Defense Logistics Agency. *Performance Specification: Military Combat Eye Protection (MCEP) System*. Washington, DC: US Dept of Defense; January 9, 2013. MIL-PRF-32432(GL).
17. *Department of Defense Test Method Standard: V50 Ballistic Test for Armor*. Aberdeen Proving Ground, MD: US Army Research Laboratory; December 18, 1997. MIL-STD-662F.
18. Karpenko A, Ceh M. Experimental simulation of fragmentation effects of an improvised explosive device. Presented at the 23rd International Symposium on Ballistics, Tarragona, Spain; April 2007.
19. Song JW, Lofgren J, Hart KD, et al. Aromatic Nylons for Transparent Armor Applications. Natick, MA: Soldier Systems Center, US Army Research, Development and Engineering Command; November 2006. Available at: <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA481774>. Accessed March 11, 2016.
20. Goldman, LM, Hartnett TM, Wahl JM, Ondercin RJ, Olson KR. Recent advances in aluminum oxynitride (ALON) optical ceramic. *SPIE Proceedings*. Vol 4375; September 7, 2001. Available at: <http://spie.org/Publications/Proceedings/Paper/10.1117/12.439195>. Accessed March 11, 2016.
21. Geim AK, Novoselov KS. The rise of graphene. *Nat Mater*. 2007;6(3):183-191. Available at: <http://www.nature.com/nmat/journal/v6/n3/full/nmat1849.html>. Accessed March 11, 2016.

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The US Army Medical Department Email Teleconsultation Program

Charles M. Lappan, MPA, MBA

ABSTRACT

The US Army Surgeon General authorized the formation of an email based teleconsultation program in 2004 to support deployed healthcare providers in Iraq and Afghanistan. The program, which began its 12th year of operation in April 2015, was originally viewed as a temporary solution until a robust system was fielded. Although future of the program as a going concern has not been determined, there is the possibility it could be incorporated into the critical care consultation program managed at an Army Medical Center.

BACKGROUND

In 2003, a study of dermatological evacuations from the Middle East showed that some conditions could have been managed at the forward operating base if the provider had access to a formal reach-back program.¹ A team of clinicians along with information management, quality assurance, and operations management personnel developed an email teleconsultation program. A pilot program began in April 2004. Deployed providers sent an email with or without photographs to an email utility account using the Army Knowledge Online (AKO) domain. Emails were forwarded to a contact group using the amedd.army.mil domain populated with the consultants' military email addresses. The standard was to answer a consultation within 24 hours of receipt.

The program was an immediate success. Ophthalmology was added in July 2004 with burn-trauma and infectious diseases joining in January 2005. To prepare for the end-of-life-cycle of the AKO utility accounts, the program transitioned to utility accounts using the Defense Information Systems (DISA) domain.

The program is available to deployed healthcare providers of all branches of the US military. In October 2008, the US Army Medical Command and the Supreme Headquarters Allied Powers Europe signed a memorandum of understanding to permit North Atlantic Treaty Organization healthcare providers deployed to Afghanistan to use the program.* Deployed providers include physicians, physician assistants, nurses, independent duty medical technicians, and Special Forces medics.

There are 20 specialties with utility accounts and contact groups. The dental specialty is divided into 7 subgroups. If the provider does not know which specialty to use,

*Internal military document not readily accessible by the general public.

the consultation is submitted to a generic email account. Table 1 lists specialties using DISA contact groups. Specialties which do not have a DISA contact group are shown in Table 2. These specialties are reached using the generic email account.

Figure 1 illustrates the teleconsultation program using the DISA utility account configuration.

Burn-Trauma	Jan 05
Cardiology	Sep 05
Dental	Nov 08
Dental - Endodontic / Root Canal Issues	
Dental - General Dentistry	
Dental - Implants, crowns, partial or full dentures	
Dental - Pathology in / around oral cavity	
Dental - Periodontal involving gums & transplants	
Dental - Removal of teeth, infections, implants, or fractures	
Dental involving children	
Dermatology	Apr 04
Infection Control	Sep 08
Infectious Diseases	Jan 05
Internal Medicine	Nov 06
Microbiology	Sep 08
Nephrology	Apr 05
Neurology	Oct 06
Ophthalmology	Jul 04
Orthopedics	Jul 07
Pain Management	Sep 11
Pediatrics	May 05
Preventive Medicine	Jul 06
Rehabilitation	Apr 06
Rheumatology	May 06
TBI	Mar 08
Toxicology	Jan 06
Urology	Jul 07
Generic/All Purpose/Program Help	Sep 07

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To ensure compliance with the Health Insurance Portability and Accountability Act of 1996, personally identifiable information (PII) is not transmitted. Deployed providers update the patients' healthcare record with the consultants' recommendation(s). Consultants do not receive workload credit because PII is not in the consultation.

PROGRAM BENEFITS

The major benefit to the deployed provider is its ease of operations and rapid response. The average reply time for consultations between April 2004 and June 2015 was 5 hours 15 minutes. Figure 2 shows the average reply times.

Feedback from providers has been positive. The following is a sample of comments from deployed providers:

- ▶ I have found teledermatology to be a great idea. I was able to send my patient back to performing his duties in an environment where commanders cannot afford to lose Soldiers for long periods of time. By getting brigade surgeons to email the program prior to sending them to the CSH will keep Soldiers doing their duty.
- ▶ I did not plan to do the biopsy in the field. The infection rates out here are very high, therefore we do not do anything that is elective. I will recommend to the patient that he get it removed when he gets back if it bothers him. The program has been very well received out here and has helped tremendously in the management of patients. P.S., when this Soldier came in, he had his bags with him assuming he would have to go to Germany for a biopsy; He would have if I could not have reassured him.
- ▶ This service is a real life saver! It's like having my own personal team of specialists...this is outstanding. I do not know how I did it before this service was created.
- ▶ I was truly amazed [at the response of the consultants]. The consultants jumped on the consult and the first response by Dr S got to me in the blink of an eye before I could even make my way to our TOC to run the case by the XX eye specialists. Not only did I avoid waking up the XX eye specialists last night, but more importantly avoided an unnecessary MEDEVAC.
- ▶ Wow! I only sent the consult out 10 minutes ago! Thank you!
- ▶ I am redeploying shortly, but I want to tell you how valuable this system has been. My first deployment was to XX in 2000 and if this system had been available then, medical care would have vastly improved.

The program benefits facilities that answer consultations. Internal medicine residents at the Walter Reed National Military Medical Center conduct the initial review of internal medicine consultations. Dermatologists at the

Administrative	Oncology
Allergy	Pathology
Behavioral/Mental Health	Pharmacy
Diving	Physical Therapy
Endocrinology	Plastic Surgery
Flight Medicine	Pulmonary Diseases
Gastroenterology	Radiology
Hematology	Speech Pathology
Judge Advocate General	Surgery
Neurosurgery	Vascular Surgery
Nutrition	Veterinary Medicine
OB-GYN	

Uniformed Services University of the Health Sciences and the San Antonio Military Medical Center use case studies to expose their staff to diseases they may not see at their clinics.

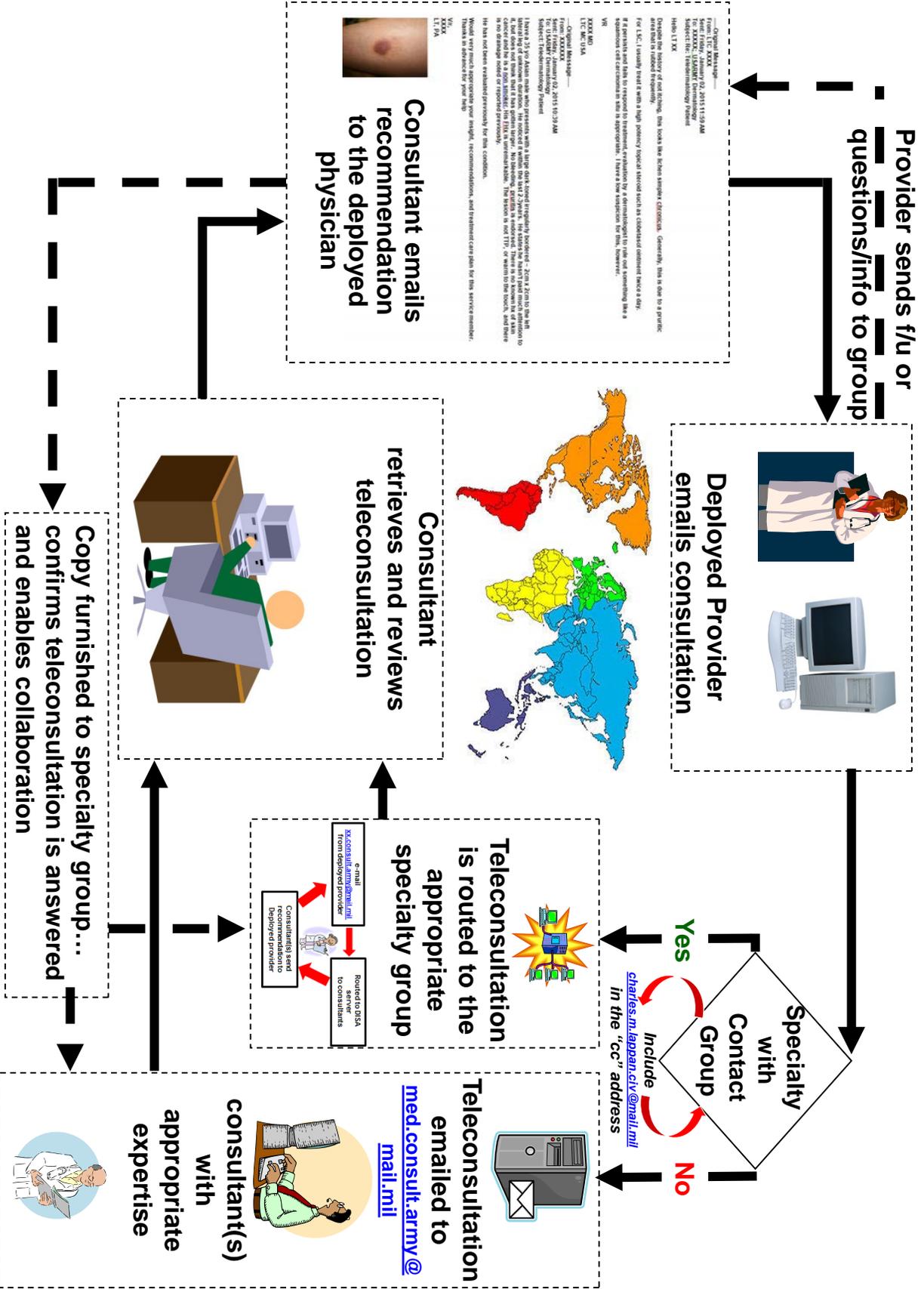
Several professional papers and posters have been published by military and Department of Defense civilian consultants. Many of the primary authors are the senior consultants for their specialty. Thirty-one papers, posters and presentations have been published since 2003. Some of the more prominent papers are included in this article's reference list.²⁻¹²

CHALLENGES TO MANAGEMENT OF THE EMAIL TELE-CONSULTATION PROGRAM: WHAT WE COULD HAVE DONE DIFFERENTLY

Managing the program had its set of problems. The majority are back-end issues. The task of the program manager is to ensure these issues do not affect the service given to the deployed provider.

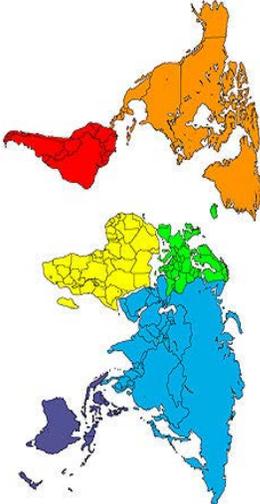
Life-cycle management was not considered when the program began. At the onset, we assumed a robust program would be developed, negating the need to include life-cycle management features. In 2005, a team studied several options. Many users requested the follow-on program include an email option. A decision was made to retain the email program in its original configuration. We did not consider what event(s) would terminate the program or how to end it in a logical manner. The program had to be renewed every 2 years through Army Medical Command memorandums.

Data is manually collected, entered, and analyzed using a combination of software in lieu of a dedicated scalable/searchable system. When the program began, only a few data elements were tracked. Information from each consultation is placed in an MS Excel file with up to 30 data points. Excel was chosen because the program

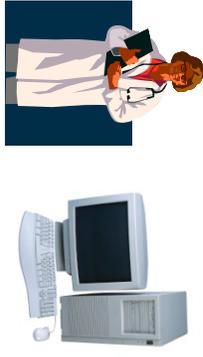


Consultant emails recommendation to the deployed physician

-----Original Message-----
 From: LTC XXXX [mailto:XXXX@XXXXXX.usa.mil]
 To: XXXXX, USAMRIID Dermatology
 Subject: Dermatology Patient
 Hello LTC
 On review of history of past lesions, this looks like Kyrion hemangioma (CHERRYANGIOMA). Generally, this is due to a proliferative overgrowth of capillaries.
 For U.S., I usually treat with a high potency topical steroid such as clobetasol ointment twice a day.
 If at present you wish to request to treatment evaluation by a dermatologist to rule out something like a melanoma, I would be glad to refer you to a dermatologist in the region.
 I have a few suggestions for this, however...
 I have a 35 yo Asian male who presents with a large dark brown irregularly bordered ~ 2cm x 2cm tan tan to black lesion on his right upper arm. The lesion is raised and has a slightly irregular border. There is no hair on it, but does not have that it has gotten larger. No bleeding, crusting is evidenced. There is no known hx of skin cancer or other medical conditions. The lesion is not IT, or warm to the touch, and there has not been evidence previously for this condition.
 Would appreciate your insight, recommendations, and treatment care plan for this service member.
 Thanks in advance for your help.
 VA
 XXXX
 LTC
 USA

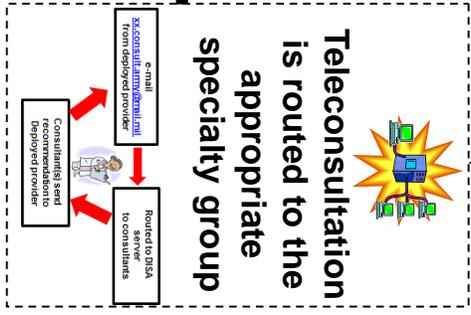


Deployed Provider emails consultation



Consultant retrieves and reviews teleconsultation

Copy furnished to specialty group... confirms teleconsultation is answered and enables collaboration



Teleconsultation is routed to the appropriate specialty group



Teleconsultation emailed to consultant(s) with appropriate expertise

med.consult.army@mail.mil



Figure 1. Process chart: Teleconsultation Program Business Practice for Deployed Providers.

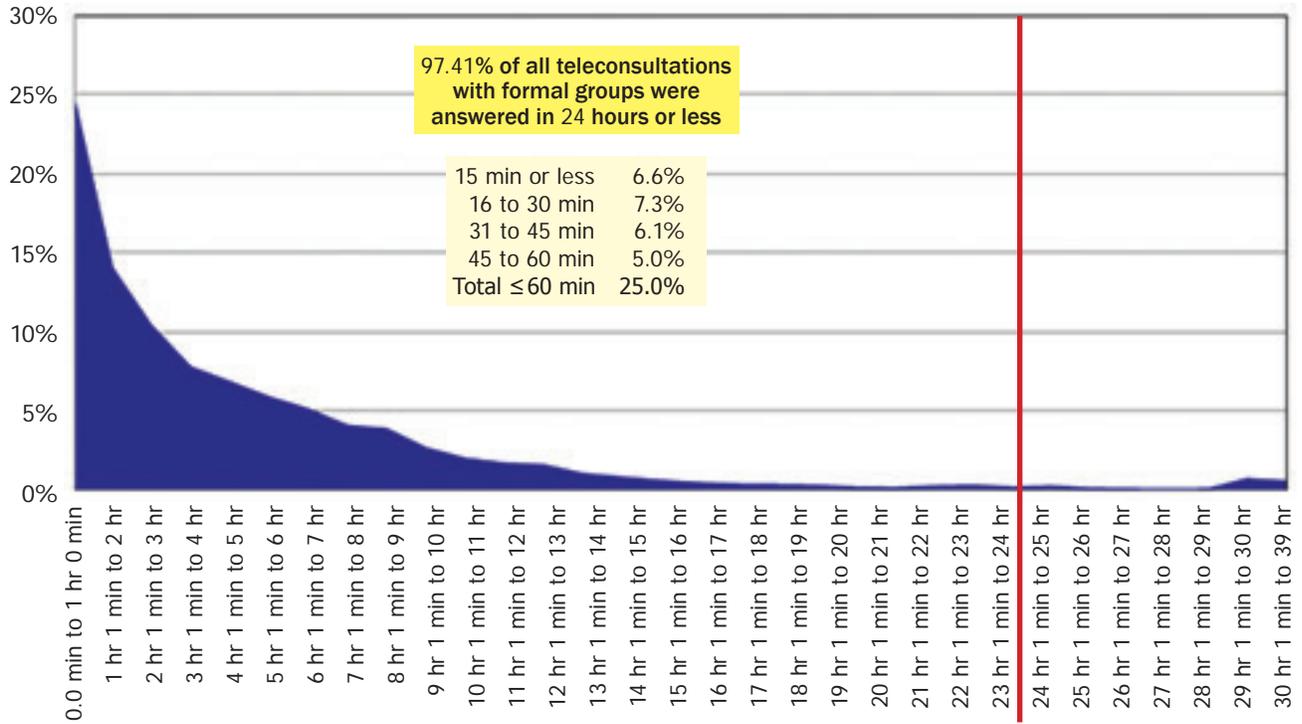


Figure 2. Reply times summary, April 2004 thru June 2015

manager was familiar with it. Data is extracted for monthly and ad hoc reports using pivot tables from 21 Excel workbooks. It takes from 6 to 8 hours to complete a monthly report. Ad hoc reports used to prepare the papers such as those listed as references 2-12 can take 12 hours or more to compile. A database program would have simplified this process.

Program management is a time-consuming process. Emails for each consultation are placed in an MS Word document. The document contains the consult text and all attachments such as photographs, electrocardiograms, x-rays, and ultrasounds. The majority of the documents are only 2 or 3 pages long. However, a number have 5 to 10 pages of emails, and a few contain 30 or more pages. The busiest period was in Fiscal Year 2011 with 1,819 consultations as shown in Table 3. The program has received consultations from 69 countries and 79 US Navy ships at sea as illustrated by Figure 3.

The program is not centrally funded. To minimize costs, the program manager performed his work as an additional duty. The US Army Telemedicine and Advance Technology Research Center (TATRC) transferred funds to the Southern Regional Medical Command, (now Regional Health Command, Central (Provisional) (RHC-C (P))), where the program manager is assigned, to offset his management of the program. Funding ceased with the drawdown from Iraq and

Year	Average Reply Time	Median Reply Time
2004	5 hr 9 min	3 hr 55 min
2005	5 hr 16 min	3 hr 32 min
2006	5 hr 12 min	3 hr 30 min
2007	5 hr 8 min	3 hr 4 min
2008	4 hr 58 min	3 hr 11 min
2009	5 hr 11 min	3 hr 10 min
2010	5 hr 13 min	3 hr 23 min
2011	5 hr 12 min	3 hr 22 min
2012	5 hr 36 min	2 hr 57 min
2013	5 hr 58 min	2 hr 54 min
2014	4 hr 1 min	1 hr 38 min
2015	4 hr 51 min	1 hr 5 min
Program	5 hr 15 min	3 hr 4 min

Time	%
0.0 min to 1 hour 0 min	25.02%
1 hour 1 min to 2 hours	14.09%
2 hours 1 min to 3 hours	10.43%
3 hours 1 min to 4 hours	7.85%
4 hours 1 min to 5 hours	6.91%
5 hours 1 min to 6 hours	5.95%
6 hours 1 min to 7 hours	5.19%
7 hours 1 min to 8 hours	4.15%
8 hours 1 min to 9 hours	3.95%
9 hours 1 min to 10 hours	2.74%
10 hours 1 min to 11 hours	2.08%
11 hours 1 min to 12 hours	1.77%
12 hours 1 min to 13 hours	1.67%
13 hours 1 min to 14 hours	1.12%
14 hours 1 min to 15 hours	0.89%
15 hours 1 min to 16 hours	0.68%
16 hours 1 min to 17 hours	0.53%
17 hours 1 min to 18 hours	0.44%
18 hours 1 min to 19 hours	0.41%
19 hours 1 min to 20 hours	0.37%
20 hours 1 min to 21 hours	0.24%
21 hours 1 min to 22 hours	0.22%
22 hours 1 min to 23 hours	0.33%
23 hours 1 min to 24 hours	0.38%
24 hours 1 min to 25 hours	0.24%
25 hours 1 min to 26 hours	0.32%
26 hours 1 min to 27 hours	0.18%
27 hours 1 min to 28 hours	0.15%
28 hours 1 min to 29 hours	0.12%
29 hours 1 min to 30 hours	0.15%
30 hours 1 min to 39 hours	0.79%
More than 40 hours	0.64%

OPERATIONAL PATIENT HEALTHCARE

Table 3. Total Consults By Fiscal Year.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	Program Totals	% Consults Program
Burn-Trauma		23	24	19	32	31	13	17	10	12	7	2	190	1.5%
Cardiology		2	67	41	61	67	84	51	32	30	36	23	494	3.9%
Dental						14	15	21	5	11	3	5	74	0.6%
Dermatology	321	543	528	468	562	526	560	543	281	231	291	154	5,008	39.1%
Infection Control						11	11	16	4	14	21	7	84	0.7%
Infectious Diseases		82	110	106	100	110	110	100	69	66	60	32	945	7.4%
Internal Medicine				34	50	57	64	70	53	29	24	15	396	3.1%
Microbiology						8	7	3	1	3	1	1	24	0.2%
Nephrology		13	18	33	30	29	20	19	19	6	9	10	206	1.6%
Neurology				78	123	145	123	129	69	40	28	21	756	5.9%
Ophthalmology	10	51	38	54	70	65	56	81	49	56	33	27	587	4.6%
Orthopedics				11	105	169	142	227	137	117	105	93	1,106	8.6%
Pain Management											3	6	9	0.07%
Pediatrics		8	21	27	24	20	15	7	6	2	2	1	133	1.0%
Preventive Medicine			3	13	13	25	26	25	23	14	12	1	155	1.6%
Rehabilitation			1	Group Discontinued									1	0.01%
Rheumatology			13	26	20	21	32	35	19	16	17	9	208	1.6%
Sleep Medicine						12	5	16	4	3	3	3	46	0.4%
Toxicology		2	19	15	14	8	14	15	11	5	4	2	109	0.9%
Traumatic Brain Injury					8	42	63	74	34	8	16	5	250	2.0%
Urology				6	69	108	114	125	64	45	39	27	597	4.7%
Other Specialties		7	62	124	178	185	180	245	136	110	113	96	1,435	11.2%
Totals	331	731	903	1,055	1,459	1,653	1,654	1,819	1,026	818	827	537	12,813	
Average Per Month	55	61	75	88	122	138	138	152	86	68	69	60	95	

Afghanistan. The RHC-C (P) continues to support the program without reimbursement from the Army Medical Command. The hospitals of the consultants are not reimbursed for their work, nor is there any way for the consultants to account for their time.

The program manager does not have a formal backup. During long absences, a staff member at the RHC-C (P) monitors but does not actively manage the program. This leaves a backlog of work for the program manager. It creates a single point-of-failure if the program manager is not able to fulfill his duties. A formal backup would permit the program manager to disengage from his duties and reduce the likelihood of burnout.

Lack of awareness of the program by deployed providers. Creating awareness of the program to deployed providers is an ongoing issue. Several organizations said they were not interested in the program. The Army Medical Department Center and School (AMEDDC&S), Joint Forces Trauma Conference (JFTC) is the program's biggest supporter. The program manager has spoken at almost every JFTC conference for the last 5 years. Briefings are conducted at the AMEDDC&S Medical Corps and Physician Assistant courses. Many providers learn about the program from their colleagues after they

arrive at their deployed location. Most providers send only a few consultations. A few "super-users" have sent over 50 consultations.

The program cannot accept classified consultations. The potential to mix classified with unclassified consultations is an unacceptable risk.

The program is not linked to the patient's healthcare record. Deployed providers are responsible to update the patients' healthcare records. There is no formal way to determine if the consultant's advice is followed and if the patient is evacuated or managed in theater.

Bandwidth issues. Early in the program, some providers had difficulty submitting consultations of more than 2 MB in size. Several facilities in the United States blocked emails that were greater than 10 MB. When large consultations were received, the program manager compressed and retransmitted them to the consultants.

Spam and phishing. Well-meaning users posted the email addresses of the utility accounts in public facing websites. There were several instances in which spammers sent emails to every group. Over 600 consultants participated at the height of the program. If the

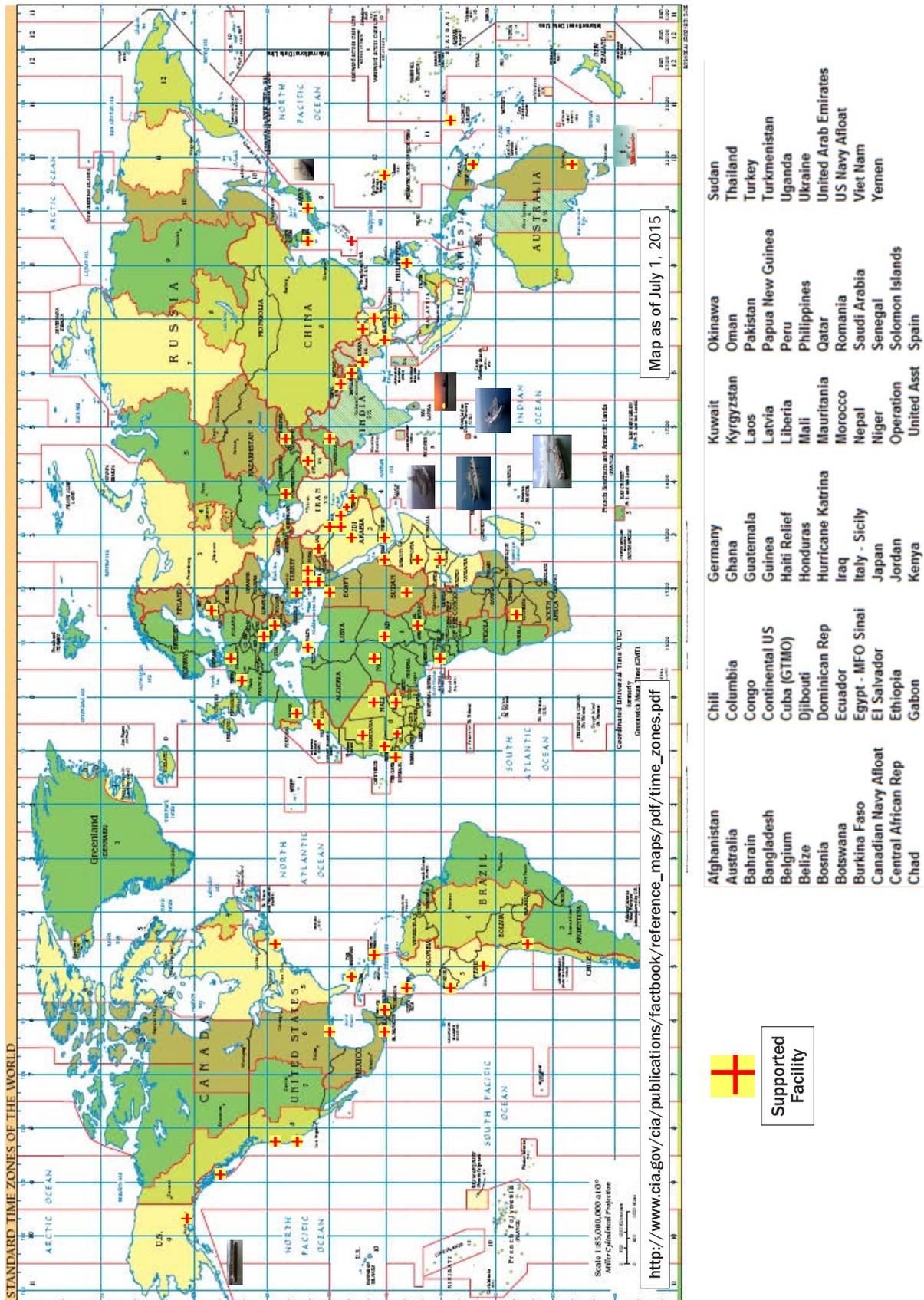


Figure 3. Locations submitting teleconsultations.

consultant placed an out-of-office reply in their email box, the spammer/phisher knew the utility account was valid.

Diversion of consultations into Outlook Junk email files. Sometimes a teleconsultation was diverted to the consultant's junk email. If the consultant does not monitor the junk email box, he/she is not aware they have a consultation to answer. Modifying the Outlook rules of what is/is not junk has had mixed results.

Consultants may not respond to the specialty group when answering a consultation. A consultation is considered as "not answered" until the program manager receives a reply from a consultant. If the consultation is not answered within 12 to 20 hours, the program manager retransmits the consultation. Consultants who respond directly to the deployed providers are instructed to forward their reply to the group.

Deployed providers may not respond to the entire group when a consultant asks for additional information. If a consultant requests additional information from the deployed provider and the provider does not respond to the entire group, the consultant forwards the reply to the entire group.

There is no consistency among specialties on the management of their groups. Some groups have a gatekeeper who forwards consultations to specific consultants. Some groups have consultants who answer all consultations for a specific period. Other groups place specific hospitals on call for a specific month(s). The majority of the specialties do not place specific consultants on call. The first consultant to answer a consultation retains control of it.

Poorly-focused patient photographs. Most deployed providers use their personal camera or camera phone to take photographs. They may not be skilled in fundamental digital photography techniques. When a poorly focused photograph is received, the program manager determines the camera make and model and its settings from the Exchangeable Image File Format (EXIF) embedded in the photograph. He instructs the provider how to take diagnostically acceptable photographs. In several instances, this has resulted in a change to the consultant's diagnosis. There is no way to know whether legal authorizations to take and transmit photographs of patients have been observed. There is no way to prevent personally identifying information from being included in photos.

DOTMLPF* ASSESSMENT/LESSONS LEARNED

Doctrine: The program began in 2004 with minimal fanfare. The first comprehensive Office of The Surgeon General/US Army Medical Command (OTSG/MEDCOM) Policy Memorandum was published in May 2004.¹³ Two subsequent OTSG/MEDCOM Policy Memorandums renewed the program through June 2011.^{14,15} The program was addressed in OTSG/MEDCOM policy Memorandum 13-009 (2013) and OTSG/MEDCOM Policy Memo 15-020,^{16,17} (2015) and incorporated into the current OTSG/MEDCOM telehealth policy in 2013.¹⁸

Organization: The program relies on volunteers participating as an additional duty. Because the program was envisioned as an interim solution, long-term sustainability was not considered.

Training: Only a few mobilization stations briefed deploying providers on the program. On several occasions, the program manager was informed that the pre-mobilization training schedule did not have any time available/allocated to brief healthcare providers concerning the teleconsultation program. A 50-minute briefing is presented to deploying providers at the Joint Forces Trauma Course at Fort Sam Houston, Texas.

Materiel: TATRC purchased laminated credit card size cards to distribute to deploying and deployed providers. Funding for the cards ceased when TATRC was no longer able to offset the program managers' expenses.

Leadership and Education: The AMEDDC&S schedules telehealth presentations to the Medical Corps and Physician Assistants officer basic and career courses.

Personnel: Not applicable.

Facilities: Not applicable.

REFERENCES

1. Pak H. Presentation at Dermatology Conference, Great Plains Regional Medical Command Headquarters, Fort Sam Houston, Texas; August 2003.
2. Poropatich RK, DeTreville, Robert, Lappan Charles M, Barrigan, Cynthia, The U.S. Army telemedicine program: general overview and current status in Southwest Asia. *Telemed J E Health.* 2006;12(4):396-408.

* Doctrine, organization, training, materiel, leadership & education, personnel, facilities.

THE ARMY MEDICAL DEPARTMENT JOURNAL

3. Morgan AE, Lappan CM, Fraser SL, Hospenthal DR, Murray CK. Infectious disease teleconsultive support of deployed healthcare providers. *Mil Med.* 2009;174(10):1055-1060.
4. Rand ER, Lappan CM, Lee JC, Furgerson JL. Paging the worldwide cardiology consultant: the Army Knowledge Online Telemedicine Consultation Program in cardiology. *Mil Med.* 2009;174(11):1144-1149.
5. Mines MJ, Bower KS, Lappan CM, Mazzoli RA, Poropatich RK. The United States Army Ocular Teleconsultation Program 2004 through 2009. *Am J Ophthalmol.* 2011;152(1):126-132.
6. Blank E, Lappan C, Belmont PJ Jr, Machen MS, Ficke J, Pope R, Owens BD. Early analysis of the United States Army's telemedicine orthopaedic consultation program. *J Surg Orthop Adv.* 2011;20(1):50-55.
7. Schmidt T, Lappan CM, Hospenthal DR, Murray CK. Deployed provider satisfaction with infectious disease teleconsultation. *Mil Med.* 2011;176(12):1417-1420.
8. McKoy K, Norton S, Lappan C. *Quick Guide to Store-Forward Teledermatology for Referring Providers* [internet]. American Telemedicine Association; April 2012. Available at: https://accessderm.aad.org/img/ATA_Telederm_Guidelines.pdf. Accessed March 15, 2016.
9. Yurkiewicz IR, Lappan CM, Neely ET, Hesselbrock RR, Girard PD, Alphonso AL, Tsao JW. Outcomes from a US military neurology and traumatic brain injury telemedicine program. *Neurology.* 2012;79(12):1237-1243.
10. Hwang JS, Lappan CM, Sperling L, Meyerle JH. Utilization of telemedicine in the U.S. military in a deployed setting. *Mil Med.* 2014;179(11):1347-1353.
11. McManus J, Salinas J, Morton M, Lappan C, Poropatich R. Teleconsultation program for deployed soldiers and healthcare professionals in remote and austere environments. *Prehosp Disaster Med.* 2009;23(3):210-216; discussion 217.
12. Alphonso AL, Lappan CM, Tsao JW. Military telemedicine. In: Tsao JW, Demaerschalk BM, eds. *Teleurology in Practice A Comprehensive Clinical Guide*. New York, NY: Springer Science & Business Media; 2015:27-37.
13. Office of The Surgeon General/US Army Medical Command Policy Memorandum 04-003: Use of Teledermatology Consults Prior to Patient Evacuation from Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF) Locations. Fort Sam Houston, Texas: US Army Medical Command; May 2004.
14. Office of The Surgeon General/US Army Medical Command Policy Memorandum 07-009: Use of Army Knowledge Online (AKO) Email in Support of Electronic Telehealth Medical Consultation by Deployed Providers. Fort Sam Houston, Texas: US Army Medical Command; March 2007.
15. Office of The Surgeon General/US Army Medical Command Policy Memorandum 09-034: Use of Army Knowledge Online (AKO) Email to Conduct Electronic Medical Consultation. Fort Sam Houston, Texas: US Army Medical Command; June 4, 2009. Available at: https://www.qmo.amedd.army.mil/credentialing/09_034.pdf. Accessed March 15, 2016.
16. Office of The Surgeon General/US Army Medical Command Policy Memorandum 13-009: Use of Telehealth in the United States Army Medical Command (MEDCOM). Fort Sam Houston, Texas: US Army Medical Command; February 20, 2013.
17. Office of The Surgeon General/US Army Medical Command Policy Memorandum 15-020: Use of Telehealth in the United States Army Medical Command (MEDCOM). Fort Sam Houston, Texas: US Army Medical Command; February 10, 2015.
18. Office of The Surgeon General/US Army Medical Command. Telehealth All-Specialty Standard Operating Procedures. Fort Sam Houston, Texas: US Army Medical Command; May 13, 2013.

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Cardiovascular Complaints Among Military Members During Operation Enduring Freedom

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ABSTRACT

During Operation Enduring Freedom, the US military began deploying a dedicated theater cardiology consultant to Afghanistan in an effort to increase rates of return to duty in service members with cardiovascular complaints. This study was designed to categorize these complaints and determine the effect on both aeromedical evacuation and return to duty rates during a 2.5 year observation period. A total of 1,495 service members were evaluated, with 43% presenting due to chest pain followed by arrhythmias/palpitations (24.5%) and syncope (13.5%). Eighty-five percent of individuals returned to duty, most commonly with complaints of noncardiac chest pain, palpitations, or abnormal electrocardiograms. Fifteen percent were evacuated out of theater, most often with acute coronary syndrome, pulmonary embolus, or ventricular tachycardia. The forward-deployed theater cardiology consultant is vital in the disposition of military members by effectively parsing out life threatening cardiovascular conditions versus low risk diagnoses that can safely return to duty.

The US military is not immune to the global scourge of cardiovascular disease. Cardiovascular disease has affected service members throughout history and continues into the current war on terror. Autopsies of US service members killed in the Korean and Vietnam wars demonstrated an 8.5% prevalence of coronary atherosclerosis.¹ Unfortunately, coronary artery disease is not uncommon in military members and only increases with age and traditional cardiovascular risk factors.

Operation Enduring Freedom (OEF) Afghanistan is a United States-led coalition military action focused within Afghanistan that took place from October 2001 to 31 December 2014. The involvement of the US military in Afghanistan remains ongoing under Operation Freedom's Sentinel. This operation functions alongside the International Security Assistance Force which is supported by the North Atlantic Treaty Organization. There have been over 1 million deployments of US service members in support of OEF, and 3,495 fatalities of US and coalition forces.² Based on limited data from Operation Iraqi Freedom (OIF), evacuation from the operational theater for known or suspected disease of the cardiovascular system is not uncommon.³

Rates of clinically evident cardiovascular disease in OIF have been evaluated. A pilot study was performed to evaluate the value of a forward-deployed cardiologist in the operational theater. The cardiologist was equipped

with exercise testing equipment, an ambulatory electrocardiographic monitoring system, and transthoracic echocardiography capabilities. Results from this study demonstrated a marked increase in return to duty rates ranging from 85% to 89% when a cardiologist determined disposition of the servicemember.^{3,4} To further validate these findings and mitigate the morbidity and mortality risks associated with acute cardiovascular disease, the US military began deploying a theater cardiology consultant to Afghanistan in 2010. The theater cardiology consultant was stationed at Bagram Air Field, a strategically placed casualty collection point near the primary site for air evacuations out of Afghanistan. The theater cardiology consultant is able to perform electrocardiograms, ambulatory electrocardiographic event recording, graded exercise stress testing, transthoracic and transesophageal echocardiograms, and stress echocardiography. We prospectively categorized patients referred for theater cardiology evaluations based on their primary cardiovascular complaint and assessed the disposition of those service members involved with OEF from 2010 to 2013.

METHODS

Study Population and Setting

Data were collected prospectively from all patient encounters seen by the theater cardiology consultant from November 2010 to September 2013 at the Role III medical facility at Bagram. The data set included demographics,

primary cardiac diagnoses, and disposition (evacuation or return to duty). Enrollment criteria included all foreign and American military members who presented to this facility with a cardinal manifestation of possible cardiovascular disease. Afghani nationals and children were excluded from analysis. The theater institutional review board approved the protocol.

Cardiac diagnoses were selected by the theater cardiology consultant using a list of standard cardiovascular diagnostic terms. Diagnoses were grouped into diagnostic related groups if the overall incidence of disease was low. Clinically relevant arrhythmias were analyzed using the most specific diagnosis reported by the theater cardiologist. Ischemic evaluations were categorized as those with nonischemic chest pain, acute coronary syndrome, or ischemic heart disease and analyzed regardless of presenting symptoms. Acute coronary syndrome was diagnosed clinically using standardized published criteria.³ Specific arrhythmias included atrial fibrillation, atrial flutter, supraventricular tachycardia, ventricular tachycardia, sinus bradycardia, ectopic beats, and sudden cardiac death. Abnormal electrocardiogram included diagnoses such as bundle branch block, ventricular hypertrophy, and atrial enlargement.

The disposition of each patient was clinically determined at the time of the final encounter by the theater cardiology consultant. Patients were either allowed to return to their units and resume their mission (return to duty), or were evacuated out of theater, often with a medical attendant (aeromedical evacuation).

Statistical Analysis

Statistical analysis was performed using SPSS Statistics for Windows (version 22.0; IBM Corp, Armonk, New York). Categorical variables (frequencies) were compared using χ^2 statistics. A *P*-value less than .05 was considered significant.

RESULTS

Participants

Patient demographic data are summarized in Table 1. A total of 1,495 service members were evaluated over a 34-month observation period. The US Army constituted the largest segment of the population with 1,106 patient encounters accounting for 74% of the total population.

Branch of Service	Frequency (Total: N=1,495)	%N
Coalition Soldier	81	5.4
US Forces		
Army	1,106	74.0
Air Force	103	6.9
USMC	30	2.0
Navy	48	3.2
Unknown branch	127	8.5
Mean Age: 36 years (range 18-64)		
Rank	Frequency (Total: N=1,495)	%N
None indicated	84	5.6
E-1 to E-4	379	25.4
E-5 to E-9	656	43.9
W1 to W5	74	4.9
O-1 to O-4	206	13.8
O-5 to O-9	94	6.2
Unknown	2	0.1

Enlisted soldiers and noncommissioned officers accounted for 1,034 patient encounters. The mean age of the population was 36±10 years.

Primary Findings

Table 2 delineates the frequency of each specific diagnosis. The most common reason for evaluation by the theater cardiologist was to determine the presence of ischemic heart disease. A total of 646 chest pain evaluations were performed in theater, comprising 43% of the total cardiovascular evaluations. Of the chest pain evaluations, 34 were determined to have acute coronary syndrome (2.2%) including ST or non-ST elevation myocardial infarction. The next most common diagnoses were related to primary rhythm issues such as aborted sudden cardiac death, palpitations, ectopic beats, atrial fibrillation, ventricular pre-excitation or ventricular tachycardia (24.5%). This was followed by syncope (13.5%), abnormal resting electrocardiogram (7.1%), risk factor assessment (4.3%), structural heart disease (2.7%), and perimyocarditis (2.5%).

Overall, 225 (15%) of all individuals evaluated by the theater cardiologist were evacuated out of theater and did not return to duty. The return to duty rate after being evaluated by the theater cardiology consultant was 85%. Once categorized with a specific diagnosis, the incidence of evacuation for patients with a cardiovascular diagnosis significantly exceeded the overall 15% evacuation rate for perimyocarditis (46%), pulmonary embolism (87%), acute coronary syndrome (100%), supraventricular tachycardia (43%), ventricular tachycardia (67%), and atrial fibrillation/flutter (37%). Conversely, the incidence of evacuation for patients who were diagnosed with abnormal resting ECG (4%), risk factor assessment (3%), noncardiac chest pain (8%), and palpitations (6%) were significantly less than the overall 15% evacuation rate (*P*<.05).

COMMENT

This study is the first to describe the spectrum of cardiovascular disorders evaluated by a dedicated forward-deployed cardiologist during wartime operations. The most frequent encountered complaint involved concerns for myocardial ischemia (43%). Complaints of this nature are evaluated with a thorough history and physical, electrocardiogram, and often a gated exercise stress test with or without echocardiographic imaging. While

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many primary care physicians are able to perform exercise stress testing, the cardiologist's experience in evaluating chest pain syndromes aids in the decision to return these service members to full duty. Noncardiac chest pain was the most frequently used diagnostic category (40.7%), but included among those were service members with true obstructive cardiovascular disease and acute coronary syndrome (2.3%). The risk to the service member that returns to duty with coronary obstruction or acute coronary syndrome is high, despite its rare occurrence. This is where the cardiovascular specialist is adept at detailed risk stratification and evaluation.

The next most common diagnostic category includes those with cardiac rhythm complaints or syncopal symptoms. In addition to the history and physical, evaluation may include an electrocardiogram, echocardiogram and ambulatory electrocardiographic monitoring. The theater cardiologist is able to perform and interpret the appropriate tests and make a rapid disposition with up to an 85% return to duty rate, including some who presented with higher risk arrhythmias such as atrial fibrillation.

A forward-deployed cardiologist serving as the theater cardiology consultant plays a vital role in maintaining a battle-ready military force, while minimizing out of theater medical evacuations. Over a 3-year period, 85% of all deployed individuals referred with a cardiovascular complaint were returned to duty. The availability of forward-deployed, first-line cardiovascular diagnostic tools, such as echocardiography, stress testing, ambulatory electrocardiography, and a board-certified cardiovascular disease specialist appeared to be an effective tool in discriminating life-threatening diagnoses from benign conditions that may have resulted in inappropriate evacuation. This data suggests that the presence of an equipped cardiovascular subspecialist in the theater of operations provides military commanders a vital tool to maintain readiness; however, continued analysis is necessary to determine the optimal risk assessment tools needed in theater. In addition, the volume of patients encountered

Table 2. Frequency of diagnostic categories and effect on evacuation frequency. active duty patients displayed by diagnostic category, relative percentage of total active duty patients, number of patients receiving aeromedical evacuation (AE), and aeromedical evacuation rates by diagnostic category. P-value represents significant difference of evacuation rate from expected rate by χ^2 analysis. Odds ratio reflects odds of aeromedical evacuation by diagnostic category.

Diagnostic Category	Patients (n) (Total: N=1,495)	%N	AE	AE Frequency (%n)	P Value	Odds Ratio
Ischemia						
Noncardiac Chest Pain	609	40.7%	48	8%	<.05	0.34
Acute Coronary Syndrome	34	2.3%	34	100%	<.05	458
Ischemic Heart Disease	3	0.2%	2	67%	<.05	11.4
Total	646	43.2%	84	13%	.05	0.75
Rhythm						
Aborted Sudden Cardiac Death	3	0.2%	3	100%	<.05	40
Bradyarrhythmia	11	0.7%	3	27%	.25	2.13
Palpitations	197	13.2%	11	6%	<.05	0.27
Ventricular Tachycardia	3	0.2%	2	67%	<.05	11.4
Atrial Fibrillation/Flutter	71	4.7%	26	37%	<.05	3.3
Supraventricular Tachycardia	23	1.5%	10	43%	<.05	4.5
Ectopic Beats	48	3.2%	4	8%	.19	0.50
Pre-Excitation	12	0.8%	2	17%	.87	1.13
Total	368	24.5%	61	17%	.35	1.2
Syncope						
Presyncope/Syncope	202	13.5%	29	14%	.77	0.94
Electrocardiogram						
Abnormal ECG	106	7.1%	4	4%	<.05	0.21
Risk Factor Assessment	65	4.3%	2	3%	<.05	0.17
Structural						
Cardiomyopathy/Hf/Suspected	17	1.1%	5	29%	.10	2.4
Valvular Heart Disease	23	1.5%	0	0%	<.05	0.12
Congenital	1	0.1%	0	0%	.67	1.8
Total	41	2.7%	5	12%	.60	0.78
Pericarditis/Myocarditis						
Myocarditis	9	0.6%	9	100%	<.05	111
Pericardial Disease	28	1.9%	8	29%	.04	2.3
Total	37	2.5%	17	46%	<.05	5.1
Other						
Vascular Disease	6	0.4%	2	33%	.21	2.8
Pulmonary Embolism	15	1.0%	13	87%	<.05	38.8
Chest Trauma	9	0.6%	8	89%	<.05	46.8
Total	30	2.0%	23	77%	<.05	20.5

by a forward deployed cardiologist suggests that in large-scale conflicts, cardiovascular complaints are commonplace and a cardiovascular specialist strategically placed near an evacuation hub will be highly utilized. Furthermore, given the broad spectrum of cardiovascular conditions that the theater cardiology consultant can expect to encounter during a deployment, there is a requirement to ensure that military cardiologists are facile at a broad range of invasive and noninvasive tasks.

Although the theater cardiology consultant position can significantly augment a comprehensive cardiovascular prevention and treatment program for the deployed active duty service member, it is insufficient in addressing the complete need to mitigate cardiovascular risk. Pre-mobilization assessment of cardiovascular risk is also a critical component. Cardiovascular screening is not routinely assessed in all military members preparing for deployment, despite the presence of traditional clinical risk factors. Military members are required to undergo periodic health screening to assess fitness standards on a biannual to annual basis. Service members over the age of 40 also undergo a tiered cardiovascular risk screening program. Those individuals not meeting set medical fitness standards are advised not to deploy. The cardiovascular risk screening program consists of an initial risk assessment using the Framingham risk score and resting electrocardiogram. Service members with elevated risk or a coronary disease risk equivalent are referred for functional assessment with exercise or pharmacologic stress testing. Despite these screening efforts, chest pain remained a predominant complaint in theater. With the advent of more comprehensive risk assessment tools and multimodal imaging, efforts are underway to modernize cardiovascular screening and prevention programs.

The forward-deployed cardiovascular specialist has been shown to have a significant effect on the rates of return to duty. Our results demonstrating an 85% return to duty rate during OEF are consistent with prior studies that utilized a theater cardiologist during Operation Iraqi Freedom.³

An increased return to duty rate results in minimal time lost by the military member and almost immediate continuation of the military mission. Individuals who are evacuated out of theater are unlikely to return, which results in compromise of the mission until that military member can be replaced. The success of the theater cardiologist requires that they are collocated with fixed

wing aeromedical evacuation services, have the proper diagnostic tools to assess the most common cardiovascular complaints (treadmill, electrocardiogram, echocardiographic machine, ambulatory ECG monitor), have immediate access to emergency medical services and have direct control over the disposition of the patients whom they evaluate. We feel that future staffing models and doctrine should consider adding a supplementary position for a theater cardiologist in select, strategically located Role III facilities involved in large-scale theater combat operations.

LIMITATIONS

The data presented in this study underrepresents the total encounters seen and evaluated by the theater cardiologist. Additional duties of the theater cardiologist included providing humanitarian care for the Afghani population; these patients were excluded from data collection. These encounters would likely have affected the overall rates of diagnosis due to the prevalence of third world cardiovascular conditions in this population. In addition, baseline demographics, results of noninvasive and laboratory testing were not available for this analysis. Finally, a comparator arm of patients assessing evacuation rates of deployed subjects prior to the initiation of the theater cardiology program was not performed. Such data would have allowed for a more robust assessment of the effect of a theater cardiology program.

CONCLUSION

Cardiovascular complaints are common in the deployed setting. Many service members who have a cardiovascular concern are able to return to duty after evaluation due to the lack of a clinically significant disorder. There are a few, however, with significant life threatening cardiac disease who must be teased out from the large numbers of low risk patients. When given the proper tools to evaluate cardiovascular complaint, the forward-deployed theater cardiologist effectively performs this role and is vital in the disposition of military members.

REFERENCES

1. Webber BJ, Seguin PG, Burnett DG, Clark LL, Otto JL. Prevalence of and risk factors for autopsy-determined atherosclerosis among US service members, 2001-2011. *JAMA*. 2012;308(24):2577-2583.
2. Coalition Military Fatalities By Year [internet]. Operation Enduring Freedom iCasualties web page, iCasualties.org website. Available at: <http://www.icasualties.org/oef/>. Accessed September 29, 2015.
3. Sullenberger L, Gentlesk PJ. Cardiovascular disease in a forward military hospital during Operation Iraqi Freedom: a report from deployed cardiologists. *Mil Med*. 2008;173(2):193-197.
4. Nayak GS. Military cardiology under a tent. *Cardiology*. 2007;107:395-98.

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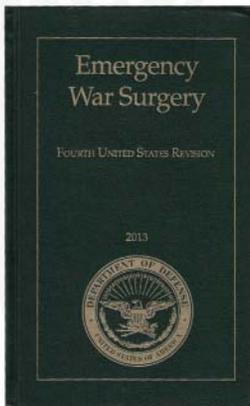
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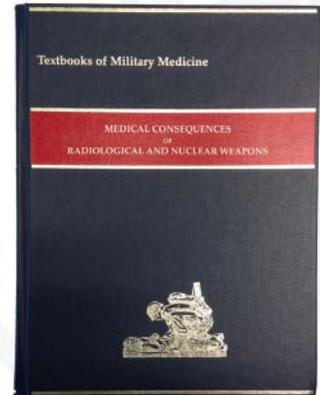


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Pediatric Wartime Injuries in Afghanistan and Iraq: What Have We Learned?

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ABSTRACT

The majority of the documented experience in pediatric trauma care during the past decade of conflict is from the inpatient Role 3 mission. Pediatric patients (defined as 14 years of age or less) accounted for 5% to 10% of combat admissions. Care for these patients was resource intensive and mortality rates significantly higher than those seen in pediatric hospitals in the United States. The largest documented experience to date with explosive injuries and massive transfusions in children were reported from this conflict. Improvements in logistic and personnel support was seen throughout the decade of conflict, however long-term outcomes and clinical practice guidelines to direct future care for these children are lacking.

Wherever there is armed conflict, the potential for injury to children exists. In Iraq and Afghanistan, the urban battlefield environment and use of improvised explosive devices have resulted in a significant amount of pediatric penetrating and blast injuries. While the primary mission of deployed combat hospitals is to care for combatants, the humanitarian care of noncombatants is inevitable. This is particularly the case in countries with a very limited medical infrastructure to handle not only both civilian combat injuries, but disease and nonbattle injury as well. Military providers deployed during the past decade cared for a significant number of children at Role 3 facilities with a broad spectrum of injuries and diseases. This experience has been documented in the Patient Administrative Systems and Biostatistics Activity (PASBA) database and the Department of Defense Trauma Registry, formerly the Joint Theater Trauma Registry (JTTR).

SCOPE OF THE PEDIATRIC MISSION

A total of 6,273 patients aged 14 years and under were hospitalized from 2002-2012 at US military hospitals in Iraq and Afghanistan.¹ The majority of those patients in Iraq over this period were due to combat injuries. The majority of patients in Afghanistan were due to non-combat related trauma and medical/congenital conditions. The primary mechanism weapon of combat injury to children in Iraq was the gunshot wound, followed closely by the improvised explosive device (IED) and other explosives. In Afghanistan, most combat injuries were due to the IED/blast injuries. Frequent indications for admission for noncombat trauma were not unlike those seen in the United States: motor vehicle collisions, falls, and burns. Admission for combat injury was significantly more likely in children over the age of 4 years. Toddlers and preschoolers were more likely to be

admitted for noncombat trauma, and infants most likely to be admitted with congenital and acquired disease.

Admissions for these patients were resource intense. Combat trauma carried a particularly high transfusion rate (greater than 25%) and need for invasive surgical procedures (more than one per patient on average). Due to data capture limitations in available data bases and limited civilian access to follow up at the military treatment facilities, outcome analysis is exceedingly limited. In-hospital mortality was 11% for combat injured children in Iraq and 8% for noncombat injured children in Afghanistan.¹ Average hospital stays were 3-5 days depending on reason for admission, combat injury being longer than noncombat injury. Nontrauma mortality was 5% in both countries.¹ Surgical procedures for noncombat injuries carried a collective mortality of less than 1%; congenital conditions requiring operation were most commonly hernia and splenectomy for congenital hemoglobinopathy.² An additional analysis of data inclusive of all patients aged less than 19 years captured through JTTR and PASBA reported 7,505 encounters between 2002 and 2011, representing 5.8% of all Role 3 admissions during that time.³ Once again, the major etiology of these pediatric injuries was blast (37%). The length of admission was inversely proportional to age, with the longest stays belonging to pediatric patients. Wound debridement and skin grafting were noted to be the most common procedures performed on these patients. Approximately 10% of patients required transfusions and 16% and 17% required ventilator support in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) respectively.³

In the above mentioned report which included older teenagers (up to age 19), notable differences were found

when children younger than 8 years were compared with those 8 years and older. Patients younger than 8 years were admitted more for medical/burn/blunt injuries, while the penetrating/blast injuries occurred more often in the older group, which likely included some combatants. Female patients were the significant majority in the younger group, while male patients were the majority in the older group. Both groups' injury severity scores (ISS) did not differ significantly, and ISS was noted to be higher in Iraq than Afghanistan. In keeping with a prior report,⁴ patients younger than 8 years of age had a higher mortality of 9.9% (trauma mortality was 10.3%), than children aged 9 years and older (5.3% overall and 7.3% trauma). The overall mortality of both groups was 8.5%.

Pediatric admission rates clearly followed the severity of the conflicts, with the majority of both combat and noncombat related admissions seen during troop surges (2008 in Iraq and 2010 in Afghanistan).¹ This implies that the need for pediatric care was not only due to the rate of children injured from the conflict, but an inability of the local community to care for children with disease and noncombat injury during these periods of time. The vast majority of children were also lost to follow up after discharge. What is also clear from the 2 studies is that while traumatic injuries carried high mortality rates for children, nontrauma admission mortality rates are also high, suggesting deficiencies in the baseline health of this population and local healthcare infrastructure. This data is significantly limited by selection bias, as admissions were largely at the discretion of the medical treatment facility, and also subject to theater medical rules of engagement. Data is further limited by absence of available age for a significant number of patients entered into the database.^{1,3}

BLAST INJURIES

A study of blast injuries for all civilians treated in military treatment facilities in Iraq and Afghanistan from 2002 and 2010 found a large portion of patients were children under age 15 (24.5%). Detonation of IEDs and injury secondary to unexploded ordinance detonation were the most common cause of blast injury. Seventy percent of these blast injuries were noted to affect multiple body regions.⁴ Burns and external injuries were noted to be the most frequently body region injured (70%). Death most strongly associated with severe burn injury, followed by injuries to head and cervical spine. This study showed a mortality for children 15 years and younger to be 7.8%. Analysis of the surgical interventions performed for these blast injuries was also performed, documenting the care for 1,213 patients who were 14 years or younger.⁶ Once again; wound debridement and wound closure

were the most common procedures and were followed by vascular access, exploratory laparotomy, and thoracostomy. Most of the procedures performed on pediatric patients were for patients aged 4 to 14 years. Children aged 9 to 14 years had the highest number of interventions and the highest ISS. Children younger than 3 years of age did not receive operative treatment comparable to older groups even though their injury severity and mortality were higher.⁵

Fragments from blast injuries resulted in a significant experience with pediatric vascular injury. In a report of 155 pediatric vascular injuries from the wars, 58% were attributed to blast mechanism.⁷ Lower extremity wounds were the most prevalent, followed by upper extremity and torso. Torso vascular injuries were double the rate seen in adult studies, and were 4 times more lethal than other injury patterns, accounting for 70% of the mortalities due to these injuries. Pediatric mortality in this study was 9%, similarly to previously reported figures.¹⁻⁷ The rate of limb salvage was 95% and consistent with prior pediatric literature; however, long-term outcome data for the revascularization procedures is unavailable.

Blast injuries in OEF an OIF were common and accounted for a major portion of injuries suffered by children. These injuries have unique combination of penetrating, burn, and blunt mechanisms in addition to the tissue damage sustained from atmospheric overpressure. Children are particularly susceptible to these injuries. Unfortunately, this mechanism is likely to be seen outside of the battlefield in future terrorist attacks.

RESUSCITATION AND TREATMENT OF HEMORRHAGIC SHOCK IN CHILDREN

Data from OEF/OIF captured 1,113 pediatric admissions who received blood transfusion in the first day of their hospital stay.⁸ Multivariate analysis evaluated mortality against the amount of blood products transfused. This revealed that approximately 40 ml/kg of blood products transfused provided a clear cut point for increase in mortality. The group receiving less than 40 ml/kg was compared against the group receiving more. The high volume transfusion group was significantly more likely to suffer from explosion injuries, higher ISSs, lower GCS, and shock. This is confirmed by previous studies reporting 9.6% transfusion rate in all pediatric injuries and 14% to 17% transfusion rate for blast injuries.^{1,3} Mortality during the first 24 hours and totals in hospital mortality were significantly higher in the group transfused more than 40 ml/kg.⁸ This data provides a possible starting point to define massive transfusion in pediatric trauma patients that is independent of the

injuries they sustained and may serve to be an indicator for increased mortality. This data is limited by poor capture of weights in 40% of these patients, as well lack of data from point of injury, failure to include severe head injuries, and retrospective design.

Further analysis of patients aged under 15 years who received transfusion at military treatment facilities looked at the effect of balanced component blood product resuscitation and crystalloid avoidance as a resuscitation strategy. Two hundred twenty-four patients received more than 40 ml/kg of packed red blood cells (PRBCs) or whole blood, and 77 received more than 70 ml/kg. Balanced component resuscitation with a 1:1 ratio of PRBCs to fresh frozen plasma did not improve mortality in either of these groups, and, when all transfused patients were considered, was independently associated with increased mortality. Use of crystalloid in excess of maintenance requirements was associated with increased hospital and ICU stays in both the 40 ml/kg and 70 ml/kg groups. This data is also subject to the limitations listed in the prior study, but underscores the need of clinical practice guidelines specific to pediatric patients for the initiation of damage control resuscitation strategies.⁹

Finally, tranexamic acid (TXA) has been shown reduce mortality in adult patients with hemorrhagic shock.¹⁰ Although pediatric literature exists for use of TXA in elective and nontrauma related settings, less is known about the utility and safety of its use in pediatric trauma.¹¹⁻¹³ Data obtained during 2008-2012 from Camp Bastion, a Role 3 hospital in Afghanistan, found that 9% of 766 pediatric trauma admissions received TXA. Characteristics of the group that received TXA revealed a significantly higher portion of penetrating injuries, a higher ISS, and lower GCS.¹⁴ This retrospective study reported a reduced mortality for the TXA cohort that was independent of mechanism of injury and injury severity. The authors did not report any thromboembolic complications resulting from TXA administration. The optimal dose of TXA for pediatric administration still needs to be identified, but this early evidence seems to indicate that pediatric TXA administration may improve outcomes for pediatric patients with traumatic injuries due to hemorrhage.

CONCLUSION

Over the past decade, combat hospitals were forced to respond to an unanticipated amount of pediatric admissions during the conflicts in Iraq and Afghanistan. The use of IEDs and the urban environment has led to a high proportion of pediatric blast and penetrating injuries to multiple body regions that has not been previously

reported in military literature. The data from this large sample of pediatric patients has increased our knowledge of pediatric blast injury and resuscitation from hemorrhagic shock. As the medical capabilities in the 2 theatres of war matured, logistical support and availability of personnel trained in pediatric care improved. However, given limited data from point of injury and short- and long-term outcomes, the development of evidence-based clinical practice guidelines for pediatrics has significantly lagged behind the profound advances in care for coalition forces. One lesson learned from this conflict is that pediatric care will be a significant portion of the military medical mission of the future. More robust data collection and outcome analysis, as well as training and logistical support, will be essential to care for the smallest and most innocent victims of war.

REFERENCES

1. Edwards MJ, Lustik M, Burnett MW, Eichelberger M. Pediatric inpatient humanitarian care in combat: Iraq and Afghanistan 2002 to 2012. *J Am Coll Surg.* 2014;218:1018-1023.
2. Cole W, Edwards MJ, Burnett MW. Providing care to children during times of war. *Mil Med.* 2015;180:609-611.
3. Borgman M, Matos R, Blackbourne L, Spinella P. Ten years of military pediatric care in Afghanistan and Iraq. *J Trauma Acute Care Surg.* 2012;73(6 suppl 5):S509-S513.
4. Matos RI, Holcomb JB, Callahan C, Spinella PC. Increased mortality rates of young children with traumatic injuries at a US Army combat support hospital in Baghdad, Iraq, 2004. *Pediatrics.* 2008;122:e959-e966.
5. Edwards MJ, Lustik M, Eichelberger M, Elster E, Azarow K, Coppola C. Blast injury in children: An analysis from Afghanistan and Iraq, 2002-2010. *J Trauma Acute Care Surg.* 2012;73:1278-1283.
6. Edwards MJ, Lustik M, Carlson T, Tabak B, Farmer D, Edwards K, Eichelberger M. Surgical interventions for pediatric blast injury: an analysis from Afghanistan and Iraq 2002 to 2010. *J Trauma Acute Care Surg.* 2013;76:854-858.
7. Villamaria C, Morrison J, Fitzpatrick C, Cannon J, Rasmussen T. Wartime vascular injuries in the pediatric population of Iraq and Afghanistan 2002-2011. *J Pediatr Surg.* 2014;49:428-432.
8. Neff L, Cannon J, Morrison J, Edwards MJ, Spinella P, Borgman M. Clearly defining pediatric massive transfusion: cutting through the fog and friction with combat data. *J Trauma Acute Care Surg.* 2014;78:22-29.

9. Edwards MJ, Lustik MB, Clark ME, Creamer KM, Tuggle D. The effects of balanced blood component resuscitation and crystalloid administration in pediatric trauma patients requiring transfusion in Afghanistan and Iraq 2002 to 2012. *J Trauma Acute Care Surg.* 2015;78:330-335.
10. Shakur H, Roberts I, Bautista R, et al, and the Crash-2 Trial Collaborators. Effects of tranexamic acid on death, vascular occlusive events, and blood transfusion in trauma patients with significant haemorrhage (CRASH-2): a randomised, placebo-controlled trial. *Lancet.* 2010;376(9734):23-32.
11. Crantford JC, Wood BC, Claiborne JR, Ririe DG, Couture DE, Thompson JT, David LR. Evaluating the safety and efficacy of tranexamic acid administration in pediatric cranial vault reconstruction. *J Craniofac Surg.* 2015;26:104-107.
12. Tzortzopoulou A, Cepeda MS, Schumann R, Carr DB. Antifibrinolytic agents for reducing blood loss in scoliosis surgery in children (review). *Cochrane Database Syst Rev.* 2008;16(3):26.
13. Faraoni D, Goobie S. The efficacy of antifibrinolytic drugs in children undergoing noncardiac surgery: a systematic review of the literature. *Anesth Analg.* 2014;118:628-636.
14. Eckert M, Wertin T, Tyner S, Nelson D, Izenberg S, Martin M. Tranexamic acid administration to pediatric trauma patients in a combat setting: the pediatric trauma and tranexamic acid study (PED-TRAX). *J Trauma Acute Care Surg.* 2014;77:852-858.

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Revised

Role of Human Health Care Providers and Medical Treatment Facilities in Military Working Dog Care and Accessibility Difficulties with Military Working Dog Blood Products



LTC James T. Giles III, VC, USA

ABSTRACT

The use of military working dogs (MWDs) in support of military operations has increased dramatically over recent years, as they have proven to be our most reliable deterrent to improvised explosive devices. Health-care delivery for MWDs in combat presents unique challenges and requires extensive collaboration between veterinarians and human health care providers (HCPs). A successful example is the incorporation of MWD emergency care for nonveterinary HCPs into the Joint Trauma System Clinical Practice Guidelines, which has proven to be a helpful product. Additional challenges that need further solutions include MWDs as patients in human medical treatment facilities (MTFs) and the procurement of appropriate canine blood components in an operational environment. It is often necessary for MWDs to be treated as patients in human MTFs, however, there is no Department of Defense guidance to support this activity. Access to MWD blood products is limited to collection of fresh whole blood in the operational setting. Similar to humans, specific blood component therapy, such as fresh frozen plasma, is often indicated for sick or injured MWDs. Currently there is no formal system in place to deliver any blood products for MWDs or to facilitate collection in theater.

ROLE OF THE MILITARY WORKING DOG

Military working dogs (MWDs) are used in unprecedented numbers in current military operations, and play a vital role in both protecting human lives and supporting military objectives.^{1,2} Military working dogs are trained to perform a variety of roles such as explosive, mine, and narcotic detection, patrol/attack work, special operations support, and animal assisted therapy for physical and emotional injuries, to name just a few.¹ Similar to the human service members they serve, MWDs are susceptible to both combat and noncombat related injuries in the operational environment. Contract working dogs (CWDs), which are owned by a private entity and perform a Department of Defense (DoD) mission, are also used extensively, typically performing a non-combat security mission. The need for effective MWD teams has increased significantly with the prevalence of improvised explosive devices (IED) in recent years. In 2008, GEN David Petraeus aptly noted:

The capability that military working dogs bring to the fight cannot be replicated by man or machine. By all measures of performance, their yield outperforms any asset we have in our inventory. Our Army would be remiss if we failed to invest more in this incredibly valuable resource.³

At a time when IEDs represent one of the most significant threats to our service members, MWDs remain our greatest countermeasure to that threat. It is important to remember that the purpose of the MWD is to save human lives, and maintaining their health and proficiency is critical to military operations. Anytime an MWD team detects an explosive device before it detonates, the result is that humans are not killed, maimed, or injured.

OVERVIEW OF MILITARY WORKING DOG CARE IN AN OPERATIONAL ENVIRONMENT

Veterinary care in a developed operational environment is provided by the Medical Detachment Veterinary Service Support (MDVSS). This organization has

5 Veterinary Service Support Teams with one general practitioner veterinarian (AOC* 64A) and one animal care specialist (MOS* 68T) each, to provide Role 1 and Role 2 veterinary care. There is one Veterinary Medicine and Surgery Team with a veterinary clinical medical officer (AOC 64F) and 3 animal care specialists providing Role 1-Role 3 veterinary care. As delineated in *Field Manual 4-02*,⁴ Role 1 care is nonsurgical treatment by an animal care specialist or veterinarian for minor wounds, injuries, or illnesses, preventive medicine, analgesia, emergency intervention for airway, hemorrhage, and fracture immobilization. Role 2 veterinary care includes veterinarian-directed resuscitation and stabilization and may include advanced trauma management, emergency medical procedures, and emergency resuscitative surgery. Role 3 veterinary care includes consultation and referral for advanced veterinary diagnostic, therapeutic, and surgical procedures. This level of care requires a veterinary clinical medical officer with training in surgery, internal medicine, or critical care. In the combat theater, this facility is typically collocated with a Role 3 human hospital for equipment and technical support. There is frequently only one or a partial MDVSS in a combat theater. At the height of Operation Enduring Freedom, there were 2 MDVSS units deployed to Afghanistan. Consequently, there are typically very limited numbers of veterinary providers in theater, and MWDs are often geographically separated from immediate veterinary support. The doctrinal basis of allocation is one MDVSS per 60,000 troops or 50 MWDs, which is rarely met based on the MWD numbers. Additionally, the ratio of MWDs to troops has increased dramatically in recent years due to the widespread use of IEDs.

Both MWDs and CWDs are eligible for veterinary care and medical evacuation within the combat theater (CWDs based on the provisions of the government contract). Military working dogs are also eligible for aeromedical evacuation (AE) out of the theater, however, for CWDs it is the responsibility of the owning entity to evacuate them from theater. Similar surgical principles for combat injuries are followed for MWDs and human service members, in that definitive care for significant trauma and for high-energy and contaminated wounds is often delayed until the patient is out of the combat theater. This is not the case for CWDs as they often receive definitive care and recover in theater. Procedures are occasionally performed on CWDs in theater as an alternative to euthanasia due to the expense and delay that accompanies private transport out of theater. While there is not a provision for AE of CWDs out of theater,

*AOC indicates area of concentration (an Army designation); MOS indicates military occupational specialty.

there is a mechanism for AE of human contractors when medically indicated.

HISTORY OF THE MILITARY WORKING DOG CLINICAL PRACTICE GUIDELINES

Early in the operations in Afghanistan and Iraq, it became apparent that human medicine health care providers (HCPs) frequently encounter sick or injured MWDs before veterinary providers. Consequently, each veterinary detachment developed an MWD care SOP to provide guidelines for HCPs treating working dogs in the absence of veterinary personnel. With this system, the veterinary guidance and authorized HCP scope of practice for MWDs varied with each rotation. The first MWD clinical practice guideline (CPG) was published in 2011, entitled "Canine Resuscitation," and posted on the Joint Trauma System CPGs.⁵ This document served as a provisional MWD CPG until a comprehensive product could be developed. In March of 2012, the "Clinical Management of Military Working Dogs" was published replacing the initial CPG.⁶ This document is a comprehensive CPG consisting of 106 pages and 16 appendices, which contains the full range of MWD medical topics within one CPG. The DoD Military Working Dog Veterinary Service (DoDMWDVS) served as the MWD CPG proponent and the initial tasks were authored by the instructors from the Animal Health Branch, Department of Veterinary Science, US Army Medical Department Center and School (AMEDDC&S). The CPG received extensive peer review from a broad range of veterinary corps officers (VCOs), animal care specialists, and HCPs. The DoDMWDVS continues to serve as the proponent for the MWD CPGs. The next revision will be published in 2016.

The MWD CPG begins by outlining the conditions in which an HCP should provide emergent care to an MWD, namely, in the absence of veterinary personnel when MWD life, limb, or eyesight are at risk, and to prepare the dog for emergency evacuation to definitive veterinary care.⁶ Healthcare providers are not authorized to perform routine medical, surgical, or dental care to MWDs without prior veterinary coordination and approval. Healthcare providers are cautioned that many MWDs are trained to attack and any animal that is ill or injured may respond to treatment with aggression. Military working dogs should always be accompanied by a handler. However, handlers may be killed or injured in combat and MWDs, injured or not, are a significant risk when separated from a handler. If the assigned handler is not present, it is important to identify an alternate handler as soon as possible. The MWD CPG provides information on normal clinical parameters and includes management of a number of emergency conditions, such as

airway, CPR, shock, gastric dilation volvulus, anesthesia, analgesia, and even humane euthanasia, to name a few.⁶ Healthcare providers are cautioned to only perform procedures on MWDs that fall within their clinical skill set.

ARE THE MILITARY WORKING DOG CLINICAL PRACTICE GUIDELINES USEFUL?

Anecdotally, the MWD CPGs are very helpful in providing appropriate guidance to HCPs on managing MWD emergencies. However, it is unknown how many times HCPs have provided emergent care to MWDs. Appendix Q of the CPG mandates that providers complete an after-action review (AAR) within 48 hours and provide it to the supporting veterinary unit. This self-reporting either does not occur or, if it does, is not reported to the DoDMWDVS. As part of the MWD CPG revisions going forward, AARs should go to the Defense Trauma Registry, formerly Joint Theater Trauma Registry, and DoDMWDVS.

MILITARY WORKING DOG CLINICAL PRACTICE TRAINING VENUES

The VCOs in theater are active in providing training to HCPs in MWD care. It is also common for HCPs to spend time in the veterinary hospital to gain experience. The AMEDDC&S Joint Forces Combat Trauma Management Course includes an introduction to the MWD CPGs. In recent years, VCOs have been invited to military medicine trauma symposia for MWD training. Training is always available to units, both in garrison and deployed, upon request from local or supporting veterinary units. A new development in 2015 was the addition of 15 MWD emergency critical tasks to the Critical Care Flight Paramedic (CCFP) critical task list. This is the first time HCPs have been formally assigned MWD emergency tasks and it is incorporated into the CCFP Course.

MILITARY WORKING DOGS IN MILITARY TREATMENT FACILITIES

Military working dogs in deployed settings are frequently treated in human medical treatment facilities (MTFs). This is often a necessity due to lack of veterinary facilities or existing veterinary facilities may lack needed equipment. The MWDs may require MTF support for imaging, laboratory, surgery, medical procedures, or instrument sterilization. Currently there is no DoD policy outlining MWD access to care in MTFs. While most hospitals are extremely supportive, there is often confusion and MWD access may be dependent upon case by case negotiation with MTF leadership or departmental staff. Military working dogs in garrison typically only require MTF access for advanced imaging modalities, such CT and MRI, which are beyond the scope of the

military veterinary facilities. There are Centers for Disease Control and Prevention recommendations for animals as patients in healthcare facilities which may serve as a basis for a DoD policy.⁷ Military working dogs are a crucial life-saving asset to humans serving in harm's way and it is important to ensure they have MTF facility and equipment support when the need arises.

MILITARY WORKING DOG BLOOD MANAGEMENT IN AN OPERATIONAL ENVIRONMENT

Management of MWD blood products differs greatly from the human counterpart in there is no feasible means to ship MWD blood components into the operational theater. The military logistical chain exists for cold-chain shipping of human blood components, but animal blood products are not permitted to accompany those shipments. Private transport of canine blood components is too cost prohibitive to be a solution. The organic capability of the MDVSS only supports the collection and administration of fresh whole blood (FWB). Fresh whole blood is suitable for many clinical conditions in the MWD, however, there are times when fresh frozen plasma (FFP) or platelets are a critical need. There are currently no shelf stable canine blood components available that serve as a suitable substitute.

The FWB need has been reasonably met by the MDVSS instituting a walking blood bank and prescreening donors to be available when the need for transfusion arises. This obviously takes more time than would be required if packed RBCs were available. Previously, MWDs were screened for infectious disease according to the American College of Veterinary Internal Medicine guidelines for blood donors, which involved sending out serology to Germany.⁸ The cost to support the laboratory analysis for MWDs in OIF/OEF was initially absorbed by Dog Center Europe, the Role 3 veterinary referral center located at Pulaski Barracks in Kaiserslautern, Germany. Due to fiscal constraints of the Public Health Command, that was no longer funded as of 2013. The MDVSS in Afghanistan could not secure funding by any other means for donor screening. Consequently, after 2013, MWDs selected for blood donors only received a limited disease screening based on point of care tests available to the MDVSS, putting the blood supply at greater risk for infectious disease. It is not known if any diseases have been transmitted to MWDs through this process.

The need for FFP was temporarily abated in OEF by use of plasma apheresis. In 2011, initial efforts began to develop an FFP collection and distribution program out of Kandahar Airfield (KAF). In 2012, the MDVSS obtained their own apheresis unit and it was designated for animal use only. The KAF apheresis team

was instrumental in helping to establish this capability in training veterinary personnel to operate the unit. This enabled the collection and storage of FFP at KAF and subsequent distribution to other veterinary sites throughout Afghanistan. Additionally, this apheresis unit was used to collect platelets when the clinical need occurred. This capability has been a tremendous asset for treating sick and injured MWDs in Afghanistan, however, it is an ad hoc capability that only exists in Afghanistan. It is not organic to the MDVSS for other operational environments.

At a recent Veterinary Equipment Set (VES) review conducted by the Capability Development Integration Development (formerly the Directorate for Combat Doctrine and Development) in 2015, no additional equipment or capability to support FFP collection was added to the set due to limitations in cost and weight of the VES. A plausible suggestion by the review panel was to establish an apheresis equipment push-package at Fort Sam Houston, TX, that could be shipped to a deployed MDVSS upon request.

CONCLUSION

In this article, several aspects of Doctrine, Organization, Training, Material, Leadership, Personnel, Facilities are relevant. The MWD CPGs pertain to doctrine and training. The advent of the MWD CPGs are a very useful tool to HCPs and this practice should continue. Additionally, we should maximize hands-on training opportunities for HCPs that are likely to encounter or treat MWDs. The issue of MWDs as patients in MTFs pertains to doctrine. Currently, there is no DoD policy regarding access for MWDs to MTFs. A baseline policy will ensure MWDs have appropriate access when needed, and that MTFs can implement proper infection control measures. Establishing the capability for the MDVSS to generate blood components for MWDs, most importantly FFP, relates to materiel. While it is not currently feasible to outfit every MDVSS with apheresis capability, establishing a centralized push-package is a reasonable solution until alternate shelf-stable products become available.

REFERENCES

1. Giles JT. Treatment of battlefield injuries in the military working dog: initial stabilization. Veterinary Symposium. *American College of Veterinary Surgeons 2014 Surgery Summit*. Red Hook, NY: Curran Associates, Inc; May 2015:423-425. Available at: <http://www.proceedings.com/24966.html>. Accessed March 21, 2016.

2. Giles J. Medical evacuation of the military working dog. In: *Military Veterinary Services*. Borden Institute: Joint Base San Antonio-Ft Sam Houston, TX. In press.
3. Crippen L. Military working dogs: guardians of the night [internet]. US Army website news archives. May 23, 2012. Available at: http://www.army.mil/article/56965/Military_Working_Dogs__Guardians_of_the_Night/?con=&dom=pscau&src=syndication. Accessed September 26, 2015.
4. *FieldManual4-02:ArmyHealthSystem*. Washington, DC: US Department of the Army; August 2013:11-2–11-5 Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/fm4_02.pdf. Accessed March 21, 2016.
5. Joint Theater Trauma System Clinical Practice Guideline. Canine Resuscitation. Fort Sam Houston, TX: US Army Institute of Surgical Research; April 18, 2011. Available at: http://usaisr.amedd.army.mil/cpgs/Canine_Resuscitation_18_Apr_2011.pdf. Accessed September 26, 2015.
6. Joint Theater Trauma System Clinical Practice Guideline. Clinical Management of Military Working Dogs. Fort Sam Houston, TX: US Army Institute of Surgical Research; March 12, 2012. Available at: http://usaisr.amedd.army.mil/cpgs/Clinical_Mgmt_of_Military_Working_Dogs_Combined_19_Mar_12.pdf. Accessed September 26, 2015.
7. Schulster L, Chinn RYW. Guidelines for environmental infection control in health-care facilities. Recommendation of CDC and Healthcare Infection Control Practices Advisory Committee (HICPAC). *MMWR*. 2003;52(RR-10):28-30. Available at: <http://stacks.cdc.gov/view/cdc/32395>. Accessed March 21, 2016.
8. Wardrop KJ, Reine N, Birkenheuer A, et al. Canine and Feline Blood Donor Screening for Infectious Disease. *J Vet Intern Med*. 2005;19(1):135-142.

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Select Public Health and Communicable Disease Lessons Learned During Operations Iraqi Freedom and Enduring Freedom

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ABSTRACT

History has taught us that the threat of communicable diseases to operational readiness should not be underestimated. The unique operational challenges of a decade at war in Southwest Asia have left us with many new lessons about prevention and mitigation of disease. The successes of military immunization programs demonstrated the successful application of military science to modern combat. Historic maladies such as tuberculosis and malaria continue to challenge our Army health leadership while new challenges with diseases like Q fever and rabies led to questions about our preparedness. These conflicts also brought awareness of issues about the broader deployed community, and the often unique risks that arise when US service members interact more frequently with foreign militaries, local nationals, and third country nationals. Application of these lessons to predeployment training and integration into leadership decision-making will improve our ability to maintain force readiness in future conflicts and adapt Army policy to current evidence and intelligence.

In the deployed environment, the prevention, identification, and response to communicable disease threats play a critical role in maintaining combat power. The recent wartime experiences in Iraq and Afghanistan provide no shortage of lessons learned in all of these areas of operational public health. Here we will focus on the prevention of and response to select infectious diseases of public health importance in the deployed environment. The lessons learned from these events fall into key areas of disease prevention and control, disease reporting, medical threat assessment, and risk communication. The topics chosen for discussion address lessons learned from multiple focus areas.

IMMUNIZATION

Military science is a powerful force multiplier on the battlefield. Immunization, for example, has been a staple of deployment readiness since General George Washington ordered variolation against smallpox for the Continental Army in 1777.¹ A shining example of the application of military vaccine science to the battlefield is the Hepatitis A vaccine. Hepatitis A has a long history of negatively impacting deployed forces. A successful partnership between the Walter Reed Army Institute of Research and SmithKline brought the first

hepatitis A vaccine to Federal Drug Administration approval in 1995.² In the absence of this immunization, military operations in Southwest Asia would have been at high risk for hepatitis A infection. According to the National Center for Medical Intelligence, hepatitis A virus poses a year round, high operational risk to non-immunized forces.* Despite this endemic disease threat, there were no evacuations of US service members for hepatitis A infection in Operations Iraqi Freedom (OIF) or Enduring Freedom (OEF). This was not the case for other coalition partners who reported hepatitis A infection leading to lost duty time.³ The lesson learned is that military science is important for disease prevention on the battlefield. Hepatitis A vaccine would not have come to market without the efforts of military scientists. Research and development of vaccines, medications, and military specific health programs are critical for force health protection.

Smallpox vaccine in the recent conflicts provides lessons in threat assessment and vaccine adverse event reporting. During the recent conflicts, approximately 175,000 service members were immunized annually with the current smallpox vaccine.⁴ The occurrence of

*Internal military document not accessible by the general public.

myocardial signs and symptoms secondary to the vaccine were well described in the literature with a reported incidence of 1% to 3%.⁵ As increasing numbers of service members received vaccination, case reports of myocarditis and pericarditis increased, leading to a prospective study of the use of smallpox vaccine in the deploying population.⁶ This work demonstrated an incidence of myocardial effects at a rate much higher than previously reported (10%). Of note, there was no mortality reported due to myocardial or pericardial effects of smallpox vaccine use, but the overall effect on medical readiness due to unrecognized vaccine side effects could be significant, given the number of doses administered. As the largest user of smallpox vaccine, the DoD has the responsibility to monitor vaccine safety and make recommendations on future use. The identification of higher rates of cardiac effects will lead to improved screening of cardiopulmonary risk factors for those receiving the vaccine. The question as to whether smallpox was ever a credible threat on the battlefield is debatable. However, the time, expense, and high rate of adverse events from smallpox immunization demonstrates a lesson that careful and deliberate risk assessment must be used for force health protection vaccination.

SELECT INFECTIONS OF PUBLIC HEALTH IMPORTANCE

Rabies

In 2011, a Soldier died after contracting rabies from a presumed dog bite in Afghanistan, the first rabies death in a service member since 1974.^{7,8} Rabies prevalence among feral dogs and cats was known to be high throughout much of Afghanistan.* Despite instructions contained in US Central Command (CENTCOM), General Order 01.C, prohibiting the harboring of pets or mascots while in theater, it was not uncommon for service members to keep dogs or cats as companion animals. In addition, risk was assumed in some situations when local dogs were used as sentries in remote outposts and forward operating bases, or when service members were collocated with Afghan police or military units that used canines for such purposes. Anecdotal reports from Soldiers in theater also suggested that some combat stress control officers implied that having pets or mascots was a beneficial form of stress relief and that commanders may have tolerated animal presence for morale and protection purposes. Regardless of the reasons behind such frequent interaction with feral animals, the death of a service member due to rabies made it clear that the risk from this highly lethal infection was largely underappreciated among service members and their supporting medical providers, perhaps due to the rarity of animal-to-human rabies transmission in the

United States or a lack of knowledge about the endemic risk in Afghanistan. Nevertheless, emphasis on prevention of exposure must continue to be a priority. Theater directives prohibiting the harboring of pets and mascots remain essential and commanders must ensure compliance though good order and discipline. When operational requirements place personnel at higher risk, service members must be aware of appropriate management of potential exposures, including immediate wound irrigation and medical evaluation. Medical providers must be fully trained on conducting a rabies exposure assessment. This is necessary both in operational setting and the postdeployment setting, as the inclusion of questions specific to rabies risk in the Postdeployment Health Assessment has increased the ability to detect possible exposures following deployment.

Malaria

Malaria is another infection with a historic effect on military operations. The literature is replete with case reports and epidemiologic studies defining the negative impact of malaria on combat operations. It was therefore appropriate that the military health leadership took a conservative approach to malaria prevention in Iraq. Initial prevention policy included 100% chemoprophylaxis at all times in both theaters of operations in the early stages of the Iraq and Afghanistan conflicts. Doxycycline was chosen primarily as it was also being carried as a chemoprophylactic for anthrax. Early negative experiences with this medication due to altitude and sun exposure in Afghanistan led to a curtailment of its use. The medical threat from malaria in Iraq was known to be limited. Saddam Hussain's draining of the swampy areas in Iraq had nearly eliminated the threat. Malaria in Afghanistan was focal and limited to well-defined areas. To complicate the picture, there was no standardized regimen for chemoprophylaxis across the services in the early years of the conflicts, which led to confusion, misunderstanding, or mistrust among unit providers, service members, and commanders. Chemoprophylaxis itself was suboptimal, as the medications available at the outset of combat operations, doxycycline hyclate and mefloquine, both have significant adverse effect profiles. Issues of noncompliance and adverse effects are well documented in the medical literature.⁹⁻¹² In Iraq, this led to an under-appreciation of malaria chemoprophylaxis as a Marine unit went from Iraq (very low risk) to Liberia (very high risk) and, in the absence of compliance with chemoprophylaxis, incurred 80 cases of falciparum malaria, leading to multiple hospital ICU admissions and an estimated cost of \$1.2 million to the Military Health System (MHS).¹³

*Internal military document not accessible by the general public.

By 2006, malaria chemoprophylaxis was removed from the OIF force protection plan, but cases of *Plasmodium vivax* malaria began to accumulate from OEF. Although vivax malaria poses a readiness threat to deployed forces, the low mortality and absence of drug resistance cloud the direct threat of malaria as a mortal risk to Soldiers deployed to Afghanistan, particularly considering the 30% prevalence of adverse effects from chemoprophylaxis.¹²

Mefloquine was removed as a primary chemoprophylactic medication primarily due to concern for the ability to adequately screen all service members for behavioral health contraindications.^{14,15} Fortunately, combination atovaquone/proguanil (Malarone) became readily available for use as primary chemoprophylaxis during that same time period. The low adverse effect profile of atovaquone/proguanil would improve compliance with chemoprophylaxis across the MHS.¹⁶

Multiple lessons were learned with malaria during OIF/OEF. Unfortunately, many of these lessons were in fact relearned from previous engagements, such as the notion that compliance with chemoprophylaxis depends largely on command emphasis. A new lesson learned is that being overly risk averse may negatively effect readiness. Better and faster translation of medical intelligence data into deployment policy and the ability to apply malaria prophylaxis policies below the theater level may have reduced both malaria infection and the adverse effects of chemoprophylactic medications on the battlefield. Other malaria lessons including the use of rapid diagnostic tests, empiric therapy, permethrin-treated uniforms, and public health surveillance are all equally important, and will be captured in later articles.

Tuberculosis/Latent Tuberculosis Infection

Rates of active tuberculosis (TB) transmission are high among civilian populations in both Iraq and Afghanistan. Based on this, initial force health protection measures included pre- and postdeployment placement of TB skin tests (TST) in order to identify deployment-related latent TB infection. However, the realized infection risk among US service members during OIF/OEF was quite low. The use of TSTs in low risk populations inevitably results in a large number of false positive cases. In addition, improper placement and interpretation of TSTs and variability in the biologic products used can contribute to false readings. These factors led to a number of pseudo-outbreaks of TB in which significant proportions of redeploying units were misidentified as being infected with *Mycobacterium tuberculosis*.¹⁷ In reality, despite tens of millions of contact hours with local civilians in these

countries, very few cases of active TB attributable to exposure in theater were identified. As the wars progressed, the use of risk stratification to conduct targeted testing on only those at high risk was recognized as a more appropriate approach.¹⁸ While this reduced the amount of postdeployment TB testing, returning service members were still frequently misclassified as high risk, resulting in continued testing within a recognized low risk population. MEDCOM policy eventually removed TB risk assessment from the Postdeployment Health Assessment, which proved critical in reducing the over-diagnosis and treatment of those deployed to CENTCOM areas of operation. This evolving policy highlights a misconception and a key lesson learned about tuberculosis in the operational setting. While this highly prevalent and contagious disease must always be a consideration, deployment to a country with high rates of TB on its own does not necessarily place service members at significant risk of infection. Overestimation of TB risk has notable consequences, resulting in unnecessary testing and treatment. While the adage of “a decision to test is a decision to treat” still holds true, the decision of whom to test clearly remains the more critical and difficult decision.

Human Immunodeficiency Virus

Human immunodeficiency virus (HIV) has been of limited risk to Soldiers in theater because of the systematic screening process in garrison and predeployment screening requirements. However, in 2006 and 2007 Army public health officers became aware of an increasing number of cases of HIV diagnosed on the postdeployment HIV screening test. An investigation conducted by the Military HIV Research Program and the Army Public Health Command revealed most of the infections were acquired in the predeployment window between the required predeployment screening test and the actual deployment. Other cases were acquired during mid-tour leave or immediately postdeployment. Most importantly, no infections were due to exposure within CENTCOM, including through the use of blood products in theater, particularly the battlefield blood supply (walking blood bank).¹⁹ The investigation of the HIV cluster revealed a gap in the screening process that led to deployment of HIV-infected service members. Shortening the predeployment screening window did not eliminate but did significantly decrease the risk of deploying HIV-infected service members. There are a few lessons learned from the HIV cluster. First, predeployment screening programs should consider the biology of the disease process. Given that at the time HIV testing was dependent on a positive ELISA test, and tests could have been conducted one year before deployment, exposures up to 14 months prior to deployment could have led to deployment with

HIV. In addition, this study suggests an increase in STD risk activity in the predeployment period. This may be a target for risk reduction counseling. Finally, although the assumption is made that no service members with HIV deploy into the operational environment, we know this to not be true. There are, and will continue to be, pathways by which HIV-infected Soldiers end up on the battlefield. Healthcare providers at all levels should keep this in mind in the care they provide in theater.

Q Fever

Coxiella burnetii infection, also known as Q fever, was another communicable disease that should have received greater predeployment consideration. Both Iraq and Afghanistan are countries with documented endemic Q fever risk. Exposure to this zoonotic pathogen typically occurs through the ingestion or inhalation of soil or dust contaminated by the body fluids of infected livestock. With many service members operating in agricultural regions, often in conditions that predispose to dust inhalation such as helicopter rotor wash, exposure for some was conceivable. Q fever first came to the attention of public health officials during an outbreak investigation of severe pneumonia in service members deployed to Iraq in 2003-2004.²⁰ Diagnosis of Q fever is challenging in the operational setting, as symptoms of acute infection are often nonspecific and diagnostic tests are typically not considered or are not readily available. While acute infection usually resolves spontaneously, there is a risk of chronic infection, which threatens those who remain undiagnosed. Recognition of Q fever in deployed service members led to the development of new military practice guidelines, which subsequently informed new national guidelines published by the US Centers for Disease Control and Prevention.^{21,22} The work of clinicians and public health officers led to the identification of over 150 cases of Q fever exposure in service members. Fortunately, there have been no cases of severe outcomes from chronic Q fever in US service members to date. The lesson learned with Q fever is that laboratory-based surveillance can play an important role in identifying endemic disease in deployed service members. However, it can only be useful if medical providers are aware of the endemic disease risks and have the appropriate tests available to make a diagnosis. Current and accurate infectious disease risk assessments are essential for guiding public health efforts, but they are equally important for training medical providers predeployment and identifying key diagnostic capabilities to be made available in theater.

Leishmaniasis

The early OIF experiences with leishmaniasis were well documented in the medical literature as well as in the

lay press. Environmental exposure to the sandfly vector in Iraq led to over 800 cases of cutaneous leishmaniasis. The Army Medical Department (AMEDD) struggled with how to manage these cases, including questions about evacuation, treatment, and long-term care. Despite cutaneous disease having few long-term adverse health outcomes, the large number of initial cases in service members, treatment difficulties, and media attention strained the MHS. Delayed diagnosis, delayed treatment, lack of approved diagnostics and treatments in theater led to hundreds of evacuations and lengthy treatments with a toxic investigational new drug (IND).^{23,24} The notable rise and fall of leishmaniasis cases among US service members early in OIF contributed to a new understanding about how environmental changes in the operational setting can significantly alter the ecology of this disease. As US Forces entered the country, new construction and human traffic likely contributed to a disruption of sand fly habitats, exposing a large population of immunologically naïve service members. However, the trend soon reversed as the maturing theater of operations resulted in more hardened structures and air conditioned lodging for those deployed to the region, reducing their level of exposure. The experience with leishmaniasis in OIF also changed the clinical management of cases in the deployed setting. While early cases were often medically evacuated for treatment, it became clear that conservative management of mild cases, often with a “watch and wait” approach, was a reasonable alternative that allowed many service members to remain in theater with minimal effect on long-term morbidity.

Surveillance

Given the direct relationship between health and operational readiness, accurate and timely information about disease and injury (D&I) data is critical to medical planners as well as commanders. Significant challenges were met as attempts were made to automate the collection of surveillance data. Assumptions about the use of electronic health records, training of medical providers, lack of appropriate denominator data, and bandwidth limitations posed an insurmountable barrier to systematic accurate D&I data collection in theater. Data such as hospital admissions or medical and casualty evacuation data became commonplace in reporting of D&I rates by leadership. Although easy to calculate, these metrics had limited scope and are neither useful nor actionable at the operational level. As each theater matured and medical care moved into brick and mortar structures at all levels of care, electronic health systems allowed for better capture of medical event data. However, these were still plagued by the lack of population data that would allow for the determination of rates of disease and injury.

Lack of training at the Role I level on basic collection of health surveillance data in the absence of electronic systems left a gap in our knowledge of the disease and injury picture from the earlier years of both conflicts. In the same way that Soldiers learn basic land navigation in the era of the GPS, operational medical providers should learn the importance of data collection and reporting in the absence of automated systems to monitor the health of the deployed force.

THE DEPLOYMENT COMMUNITY

The individuals and organizations that interact with the Warfighter in theater make up the deployment community. While much effort is placed on the reduction of communicable disease among service members and other US government personnel, as the theater of operations matures, greater numbers of local nationals, contractors, and third country nationals become an integral part of the deployment occupational environment. In the same way that disease surveillance, prevention, and response are important for force health protection, the same issues within the non-DoD members of the deployment community are important given the close interactions with deployed forces and other US government personnel. As contracts were put in place to hire local nationals to work on US forward operating bases, issues of occupational health screening became apparent. Third country nationals and other contractors may have had organic medical care available, but the extent of that care, the sharing of public health data, or the capacity to respond to communicable disease was unclear to Army public health officers in theater. Army preventive medicine physicians assisted with outbreaks or evaluations for disease clusters among contractors for suspected tuberculosis, varicella, meningitis, and acute diarrheal disease. The different interacting populations with disconnected medical oversight created challenges in the surveillance of diseases. The lesson learned is consideration must be made for the deployment community as a whole. Occupational health controls and disease surveillance must be ensured for all personnel working with or in proximity to US forces as a matter of force health protection.

INTEGRATION OF LESSONS LEARNED

Most of the lessons cited here are related to DOTMLPF* areas of leadership and training. Decisions about investing or maintaining military science, adherence to or command support for prevention policy, and appropriate use of risk assessments are all themes repeated in the above lessons learned. There is no doubt that Army leaders understand the connection between readiness

*Doctrine, organization, training, material, leadership, personnel, and facilities.

and disease prevention, but leaders must enforce prevention policy and the associated health behaviors in the deployed force. Additionally, leaders at all levels must use the appropriate resources, including preventive medicine assets at all levels, to make informed decisions about health risk and engage Army technical experts where such expertise exists. Army deployment policy should be based on solid medical evidence and intelligence. Finally, leaders must have the flexibility to adapt to the changing operational environment.

Training opportunities include training for all levels of medical providers in endemic disease risk as highlighted by the above discussion of rabies, malaria, and Q fever. Training medics and medical commanders on basic disease surveillance procedures while in garrison would greatly reduce the surveillance gap that we face during initial phases of deployment.

The Army doctrine related to many of these public health issues is valid, but the application on the battlefield is often difficult. As the Army moves forward towards AMEDD 2025 to support a force that is leaner, more efficient, and more integrated, commanders cannot presume that technology and medical advances will render basic military preventive medicine obsolete. The basic tenants of preventive medicine, including field sanitation, disease surveillance, and reporting, risk communication, and health risk assessment will continue to be critical to mission success. The Army must continue to field a combat force that can identify and prevent or mitigate the effect of disease and injury on deployed forces. When applied correctly, Army doctrine can achieve just that.

REFERENCES

1. Artenstein AW, Opal JM, Opal SM, Tramont EC, Peter G, Russell PK. History of US military contributions to the study of vaccines against infectious diseases. *Mil Med.* 2005;170(suppl 4):3-11.
2. Hoke CH Jr, Binn LN, Egan JE, et al. Hepatitis A in the US Army: epidemiology and vaccine development. *Vaccine.* 1992;10(suppl 1):S75-S79.
3. Green CA, Ross DA, Bailey MS. Acute hepatitis A virus infections in British Gurkha soldiers. *J R Army Med Corps.* 2013;159:240-242.
4. Montgomery JR, Engler R, Allan-Martinez F, Morse A, Duran L. Case report: chest pain in service members following smallpox vaccination. *MSMR.* 2012;19:6-7.
5. Halsell JS, Riddle JR, Atwood JE, et al. Myopericarditis following smallpox vaccination among vaccinia-naive US military personnel. *JAMA.* 2003;289(24):3283-3289.

6. Engler RJ, Nelson MR, Collins LC Jr, et al. A prospective study of the incidence of myocarditis/pericarditis and new onset cardiac symptoms following smallpox and influenza vaccination. *PLoS One*. 2015;10(3):eCollection 2015.
7. Fester JM. Public health aspects of rabies. *Aviat Space Environ Med*. 1975;46:1194-1195.
8. US Centers for Disease Control and Prevention. Imported human rabies in a U.S. Army soldier-New York, 2011. *MMWR*. 2012;61:302-305.
9. Saunders D, Garges E, Kosmowski A, et al. Doxycycline hyclate tolerability and compliance as daily oral malaria prophylaxis in field conditions: experience of the 10th Mountain Division (LI), OEF VII [abstract]. *American Journal of Tropical Medicine and Hygiene*. Abstract 1008 (page 288). Available at: https://www.astmh.org/ASTMH/media/Documents/pages_250-299.pdf. Accessed March 22, 2016.
10. Brisson P, Woll M, Brisson M. Improving compliance with malaria chemoprophylaxis in Afghanistan. *Mil Med*. 2012;177:1539-1542.
11. Kotwal RS, Wenzel RB, Sterling RA, Porter WD, Jordan NN, Petruccioli BP. An outbreak of malaria in US Army Rangers returning from Afghanistan. *JAMA*. 2005;293:212-216.
12. Saunders DL, Garges E, Manning JE, et al. Safety, tolerability, and compliance with long-term antimalarial chemoprophylaxis in American Soldiers in Afghanistan. *Am J Trop Med Hyg*. 2015;93(3):584-590.
13. Whitman TJ, Coyne PE, Magill AJ, et al. An outbreak of *Plasmodium falciparum* malaria in U.S. Marines deployed to Liberia. *Am J Trop Med Hyg*. 2010;83(2):258-265.
14. Nevin RL. Low validity of self-report in identifying recent mental health diagnosis among U.S. service members completing Pre-Deployment Health Assessment (PreDHA) and deployed to Afghanistan, 2007: a retrospective cohort study. *BMC Public Health*. 2009;9:376.
15. Nevin RL, Pietrusiak PP, Caci JB. Prevalence of contraindications to mefloquine use among USA military personnel deployed to Afghanistan. *Malar J*. 2008;7:30.
16. Kersgard CM, Hickey PW. Adult malaria chemoprophylaxis prescribing patterns in the military health system from 2007-2011. *Am J Trop Med Hyg*. 2013;89:317-325.
17. Mancuso JD, Tobler SK, Keep LW. Pseudoepidemics of tuberculin skin test conversions in the U.S. Army after recent deployments. *Am J Respir Crit Care Med*. 2008;177:1285-1289.
18. Sanchez JL, Sanchez JL, Cooper MJ, Hiser MJ, Mancuso JD. Tuberculosis as a Force Health Protection Threat to the United States Military. *Mil Med*. 2015;180(3):276-284.
19. Scott PT, Hakre S, Myles O, et al. Short communication: investigation of incident HIV infections among U.S. Army soldiers deployed to Afghanistan and Iraq, 2001-2007. *AIDS Res Hum Retroviruses*. 2012;28(10):1308-1312.
20. Shorr AF, Scoville SL, Cersovsky SB, et al. Acute eosinophilic pneumonia among U.S. military personnel deployed in or near Iraq. *JAMA*. 2004;292:2997-3005.
21. Hartzell JD, Gleeson T, Scoville S, Massung RF, Wortmann G, Martin GJ. Practice guidelines for the diagnosis and management of patients with Q fever by the Armed Forces Infectious Diseases Society. *Mil Med*. 2012;177:484-494.
22. Anderson A, Bijlmer H, Fournier PE, et al. Diagnosis and management of Q fever - United States, 2013: recommendations from CDC and the Q Fever Working Group. *MMWR Recomm Rep*. 2013;62(RR-03):1-30.
23. Weina PJ, Neafie RC, Wortmann G, Polhemus M, Aronson NE. Old world leishmaniasis: an emerging infection among deployed U.S. military and civilian workers. *Clin Infect Dis*. 2004;39:1674-1680.
24. Aronson NE, Sanders JW, Moran KA. In harm's way: infections in deployed American military forces. *Clin Infect Dis*. 2006;43:1045-1051.

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Deployment Exposures and Long-term Health Risks: The Shadow of War

Coleen Baird, MD, MPH

ABSTRACT

The victory in Operations Desert Shield/Desert Storm has been “shadowed” by long-term health concerns among returning troops. During Operations Iraqi Freedom, New Dawn, and Enduring Freedom, the Department of the Army and Department of Defense implemented recommendations of the Institute of Medicine relating to environmental exposure assessment, hazard response, documentation of exposures, and risk assessment using environmental sampling data to evaluate potential health risks among deployed troops. Recommendations regarding risk communication proved more difficult to implement, however. Exposure to particulate matter and airborne hazards including burn pit emissions and chemical warfare agents have received attention from service members, the media, and in some cases, Congress. A combination of lack of clear and consistent messages, imperfect and sometimes seemingly contradictory science, and strong perceptions suggest that questions related to these exposures and their potential long-term health effects will persist.

THE SHADOW OF WAR

A legacy of 1990-1991 Operation Desert Shield/Desert Storm (DS/DS) was the realization that the public health toll of a military conflict is not known at the time of redeployment. Beyond combat-related deaths or injuries and disease nonbattle injury (DNBI) that occur during the conflict, concerns regarding delayed health effects resulting from environmental exposures may extend the medical mission for years after the conflict has ended. The operation was considered a victory with the surprisingly low total of 145 service members dying in combat and 225 lives claimed by nonhostile actions.¹ Nonetheless, over 60,000 individuals eventually sought an evaluation as part of registry programs open to DS/DS veterans and their families.^{2,3} Widespread somatic symptoms such as pain, fatigue, rashes, and cognitive deficits were raised with concerns about their relationship to environmental exposures. Multiple expert boards and committees reviewed health consequences of service in the Gulf; none were able to define the medical nature and cause or causes of a “Persian Gulf War Syndrome,” nor identify any cause and effect relationships between putative exposures and undefined illness.^{1,3,4} The Institute of Medicine (IOM) and the Presidential Advisory Committee noted that registries established by Department of Defense (DoD) and the Veterans Administration (VA) to provide free medical evaluation to concerned Persian Gulf War veterans were not designed to answer epidemiological questions. Furthermore, available scientific evidence did not support a causal link between the symptoms/illnesses reported and exposures while in the Gulf to oil well fires, smoke, petroleum products, pesticides, chemical warfare agents, biological warfare agents, immunizations, pyridostigmine bromide, infectious diseases, or depleted uranium. However, the

investigation of possible exposures of troops was considered “superficial and inadequate.”¹ It was noted that very little personalized exposure information was available, thus it would be extremely difficult to define relevant control groups and obtain data for them. The lack of exposure data limited even the most expert and well-funded investigation to identify health outcomes linked to specific exposures or risk factors.⁴ The General Accounting Office stated that:

Without accurate exposure information, the investment of millions of dollars in further epidemiological research on the risk factors or potential causes for veterans’ illnesses may result in little return.⁵

The IOM noted that the victory in the Gulf was overshadowed by questions regarding long-term health and exposures that were known or possible for the deployed.³ This understanding is the primary public health legacy of DS/DS, and resulted in the 2000 Institute of Medicine report, *Protecting Those Who Serve: Strategies to Protect the Health of Deployed U.S. Forces*⁶ with recommended improvements.

DEPLOYMENT EXPOSURE ASSESSMENT

Presidential Review Directive 5 published in 1998 by the Clinton administration called protection of the health of our service members while deployed a “national obligation.”⁷ It directed DoD to:

...identify and minimize or eliminate the short and long-term health effects of military service, especially during deployments (including war) on the physical and mental health of veterans.

The IOM responded and recommended strategies to protect those who serve, including environmental exposure

assessments in deployment locations.⁶ They noted that the spectrum of health concerns was broadening from acute illness and injury due to pathogens and accidents to possible influences of low-level chemical exposures which can manifest in chronic illnesses years later. The IOM also noted that a useful management scheme must address all the threats that deployed forces face, so integration is particularly needed. In addition, “risk information must be presented in a way that permits rapid decisions to be made by field commanders with little pertinent expertise.”⁶ Necessary to this process are clear guidelines appropriate for deployed forces; a way to assess risk that takes into account competing risks and mission requirements. In addition, risk communication must occur on the ground. Sampling is conducted to answer questions, and those who are affected typically want to know the answers or they may draw their own conclusions. While the desire to disseminate all relevant exposure information to the affected group is strong, it is important to deliver it in an understandable way that causes neither unwarranted concern nor undue complacency.

Assessing acute risk is fairly straightforward, and the military developed both acute exposure guidelines and those considered protective for a one-year exposure for lower but continuous exposures.⁸ “Dose” relates to the magnitude, duration, and frequency of exposure. During deployment, exposure concentrations may be variable over time. Some may be for a short period but at levels high enough to immediately affect health or even degrade the mission. Regarding lower concentrations and long-term health effects: concentrations above the long-term guidelines do not necessarily pose long-term risk if the levels are intermittent. However, there is rarely sufficient monitoring information to assess levels over time in dynamic locations since sampling episodes are brief. Therefore, health risk associated with these intermittent exposures is almost always uncertain and rarely actionable, unless the action is to conduct more sampling. This can be frustrating for preventive medicine personnel and for commanders who have to choose among courses of action. The risk matrix for operational risk management classifies risk in a table as green, amber, red, and black as the risk increases.⁸ Gray (unclear results) is not in the matrix. While the IOM recommended risk communication down to the level of those exposed, the lack of clear risk and clear messages at this level interfered with this goal. In many cases, sampling was done at a unit level, but sent out of country for analysis. In most cases, a clear interpretation of the results was not available at the unit level, leaving the opportunity for inconsistent messages. According to the IOM, the acknowledgement of uncertainty does not erode trust

and confidence in leaders; instead, it fosters confidence in the reliability of the information deemed to be more certain and valid.⁶

EXPOSURE TO AIRBORNE HAZARDS

Early into Operations Iraqi Freedom and New Dawn (OIF/OND), it was recognized that particulate matter (PM) was likely to be a ubiquitous hazard.⁹ Shamal winds cause dust storms, and daily windblown dust, diesel exhaust, local pollution, and open burning were potential additional sources. It had been demonstrated that PM_{2.5} levels (representing the respirable fraction of PM) in the region had been measured at twice the US National Ambient Air Quality Standards. Exposure to PM affects the health of children, the elderly, and those with cardiopulmonary disease. The risk of various adverse health outcomes increases with exposure concentration, and there is little evidence of a threshold below which no adverse health effects are expected.⁹ The nature and probability of health effects are also dependent upon the size fraction, chemical composition, and the duration of exposure. In short, health effects were plausible, but there was a paucity of information as to the health effects of Southwest Asia (SWA) PM on a relatively young and healthy population. On the basis of concerns about the potential health effects, US Central Command (CENTCOM) approval was obtained to design and implement sampling to characterize and quantify the PM in the ambient environment at 15 deployment sites.¹⁰

While the sampling effort was remarkably successful given that the every sixth-day schedule was conducted at 15 sites and generated much information, it was difficult to tie the results to health effects. One epidemiological effort was a case-crossover study to evaluate the association between daily average PM_{2.5} and PM₁₀ concentrations at the 15 sites and acute cardiovascular and respiratory medical visits.¹¹ Results were limited because the study lacked statistical power due to the paucity of health-outcome events, and since those that occurred were not always associated with a sampling day. Another used a retrospective cohort design to examine the association between time-weighted average PM_{2.5} and PM₁₀ concentration and postdeployment cardiovascular or respiratory diagnoses in cohorts defined by deployment location.¹² No increased diagnoses rates with higher PM was found after adjustment for many confounding variables. The data were limited by potential exposure and outcome misclassification and by a relatively short follow-up period after deployment. In addition, it was recognized that base camps differ in other sources of potential airborne hazards such as industrial pollution, vehicles and fuel exposures, trash burning, and other individual contributions to respiratory or other effects.

The Committee on Toxicology of the National Research Council reviewed the available sampling information and studies and concluded that it is indeed plausible that exposure to ambient PM in SWA is associated with adverse acute and chronic health effects.¹⁰ However, the question of whether this was occurring remained. Later publications have looked at trends in respiratory conditions in the Army.^{13,14} Others have demonstrated increases in symptoms and small increases in respiratory conditions postdeployment, particularly asthma. Those studies included comparisons such as those exposed to a sulfur mine fire (Mishraq), locations with high background pollution (Kabul), and locations with and without open trash burning.¹⁵⁻¹⁷ Postdeployment respiratory effects of airborne hazards continue to be studied and are the subject of a recently published book.¹⁸

BURN PIT EMISSIONS

Once the perception of a health hazard exists, it is difficult to reassure individuals that the risk is low. Characterization of the deployed environment and health concerns of those deploying should be used to develop force protection measures and risk communication tools. Joint Base Balad (JBB) was one of the largest air bases in Iraq and was home at one point to 25,000 military, civilian and coalition personnel. Since 2003, burn pits or areas designated for burning trash were used to facilitate solid waste disposal at Balad.¹⁹ In the absence of a waste disposal infrastructure, the options for expedient disposal of trash in operational environments are burial, incineration, or a combination of the two. Tactical security considerations often limited the options to incineration as it did at JBB.²⁰ Wind roses constructed by the Air Force 14th Weather Squadron demonstrated that prevailing winds carried smoke away from locations where personnel were located. However, black smoke was often visible rising from the burn site. Under some weather conditions, such as low winds and inversions, the smoke from the burn pit lingered over areas of the base, generating complaints and health concerns amongst service members from 2003 until open burning ceased in 2009. Air sampling conducted from summer 2004 to summer 2006 demonstrated the occasional presence of volatile organic compounds and polycyclic aromatic hydrocarbons and dioxins, all of which may be associated with the open burning of trash.¹⁹ The potential health risk was estimated to be low, based on the limited detections in the small number of samples, but a more formal sampling plan was jointly developed. Four rounds of air sampling were completed; Spring and Fall 2007, Spring 2009, and Spring 2010. These air sampling efforts coincided with the introduction of initiatives to reduce exposure to burn pit smoke. Primary measures included the installation and operation of 4 solid waste

incinerators and the start of a program to segregate waste, with emphasis on the elimination of plastic water bottles from the waste stream. Two incinerators became operational in May 2007, a third in April 2008, and the last during the summer of 2009. The JBB burn pit officially closed on October 1, 2009.

Risk assessments conducted using the results of the 4 aforementioned air sampling efforts estimated cancer risk in the range considered to be “acceptable” per the US Environmental Protection Agency standards, but some volatile organic compounds were measured at levels that might be associated with acute irritation.¹⁹ These effects were consistent with health conditions reported by some personnel. It took some time for the reports to be published, and it is uncertain how well the findings were disseminated or understood by those with concerns. The VA requested assistance from the Institute of Medicine to assess air sampling data and risk assessment information from JBB. The IOM concluded that none of the individual chemicals were likely to be associated with adverse health outcomes, but that monitoring data suggests particulate matter from local and regional sources other than burn pits appeared to be of greatest concern.²¹ Risk assessments do not address mixtures of chemicals and their potential for adverse effects.^{20,22} The IOM was unable to conclude whether long-term health effects are expected from exposure to burn pit emissions. While this may be the state of the science, it does not reassure those who develop subsequent illness and might reasonably wonder if it is associated with the exposure. Congress addressed the issue in the fiscal year 2013 National Defense Authorization Act by requiring the VA to establish a registry for veterans with potential exposure to burn pits.²³ The DoD elected to expand this to service members. Participation is voluntary, and eligibility is based on deployment to OIF, Operation Enduring Freedom (OEF), and OND. Confirmation of potential exposure or deployment to specific camps or locations is not required as DoD was unable to specifically list dates and locations where trash was burned. While the actual health risk associated with burning trash may still be under study, service members, the media, and Congress viewed the billowing, thick smoke as demonstrating a lack of consideration for service members’ health, which heightened the concern. Over 50,000 service members and veterans have signed up for this registry to date, and the IOM is currently assessing the data.

CHEMICAL WARFARE AGENT EXPOSURE

Exposure to chemical warfare agents (CWA), particularly nerve agents, was a major concern after the first Gulf War due to reports of alarms, the use of the pyridostigmine bromide tablets as a nerve agent pretreatment, and

lingering health concerns after the war. Due to this, a massive research effort to address effects of low-level chemical warfare agents²⁴ was undertaken. Once again, over a decade later, CWA exposure is also an issue of lingering concern. On October 14, 2014, the *New York Times* published an in-depth investigation, "The Secret Casualties of Iraq's Abandoned Chemical Weapons,"²⁵ that initiated a landslide reaction and innovative response. The report alleged that from 2004-2011, American troops who deployed in support of OIF/OND:

...repeatedly encountered, and on at least 6 occasions were wounded by, chemical weapons remaining from years earlier in Saddam Hussein's rule.

The article noted that none of the exposed veterans were receiving long-term health monitoring. While this was not necessarily correct, there was no centralized tracking of these exposures and most of the exposure incidents were classified. The US Army Public Health Command (USAPHC) responded and by October 20, 2014, the USAPHC began contacting service member and veterans identified in the article; 17 Soldiers, 6 Marines, and 3 Sailors reported to have had symptomatic exposure to CWA, either sulfur mustard or nerve agent. The immediate task was to contact and interview these individuals and identify their exposure and their symptoms at the time, and to discuss current health concerns. Exposures for the 26 individuals occurred between 2003 and 2011, most typically from handling old leaking munitions. These munitions were either being transported for destruction, or handled during excavation, with a few exposures occurring during destruction. Mustard exposures may injure the skin (blisters), the eyes, and/or the respiratory tract depending on the dose and the route of exposure. Nerve agent exposure may cause miosis from vapor exposure to the eye, sweating, nausea, vomiting, muscle twitching, involuntary urination and defecation, or seizures and death as dose increases.

Beyond the original 26 individuals in the *New York Times* article, the USAPHC reviewed the medical records of individuals who were known to have been in the same unit of a previously identified exposed service member. In addition, in coordination with the Armed Forces Health Surveillance Center, a review of those who had identified exposure to a CWA on their Post-Deployment Health Assessment or Reassessment was initiated. By October 30, 2014, the DoD had established a toll-free hotline (1-800-497-6261) for service members and veterans to report potential chemical weapons exposure and seek a medical review. On November 7, 2014, the Under Secretary of Defense (Personnel and Readiness) designated the Army as lead agent for this response and directed the Army to develop and publish

implementation guidance for the identification and evaluation of current and former service members who had CWA exposures during their deployment to Iraq in support of OIF/OND, to be executed by all branches. On March 20, 2015, the Under Secretary of the Army issued guidelines under which service members and veterans identified as possibly exposed to a chemical weapon were to be contacted by their military service, evaluated in a structured interview, and invited for a full medical examination if they had symptomatic CWA exposure.²⁶ The participants were also to be provided with documentation of their exposure and have their medical records updated. This information was to be shared with the VA to help veterans receive follow-up care or submit claims for potentially related medical conditions. The medical examinations are being conducted at Walter Reed National Military Medical Center and Secretarial Designee status is requested for those not on active duty so that invitational travel orders may be used to pay for travel and expenses. Progress through the process and dispositions are tracked for each individual in a special module of the Defense Occupational and Environmental Health Readiness System, access to which is available to the VA. In addition, dispositions, medical history, and physical examination are documented in the individual's electronic health record.

As of October 2015, there were approximately 7,000 service members or veterans in all phases of the process of evaluation for potential CWA exposure. At the time of this writing, roughly 150 individuals were identified with symptomatic CWA exposure, all of whom have been offered a medical examination. In the vast majority of cases, no evidence of symptomatic exposure is found, although an additional 62 current and former service members were authorized a medical examination upon plainly requesting one. To date over 100 individuals have completed the medical examination process and among the completed medical examinations, no significant correlation between acute CWA exposure and chronic health effects has been identified. Nearly all exposure effects were mild (C. P. B. unpublished data). A clear lesson developed from this effort: in some exposure scenarios, testing and or monitoring resulted in mixed results. Confirmatory testing was conducted in laboratories in the United States, but service members rarely learned of the results, and the results were classified. In many cases, service members were not sure about to what they had been exposed, and thus were not sure of the potential risk that might be associated with the exposure. This resulted in both anger and frustration. The most beneficial part of the effort was that many service members had the opportunity to ask questions and come away with a better idea of their future health risk.

CONCLUSION

As in previous conflicts, many personnel returning from deployment to Iraq and Afghanistan have concerns about environmental exposures and their potential health. Exposure assessments have helped to gauge the risk, but typically are insufficient to negate risk. Transparency regarding the use and limitations of the data collected, and communication of the risks to those it affects is recommended.⁶ To support on-the-ground risk communication, the actions triggered by specific sampling results and the uncertainty surrounding these assessments should be identified prior to data collection. To the degree that results are inconclusive, it should be acknowledged that an “unclear risk” is not the same as “clear lack of risk.” It is recognized that service connection and other issues complicate these matters. Operations Iraqi Freedom, Enduring Freedom, and New Dawn were the first military operations for which specific exposure scenarios have resulted in relatively early recognition of and response to concerns in the form of a registry or other process. Registries have been developed to allow individuals to come forth and report both exposure and health concerns. These initiatives will gather information that is potentially useful to service members and their healthcare providers, as well as public health professionals who are endeavoring to protect the health of deployed troops. Though there are structural limitations to the data (for example, self-reported exposures and outcomes, and limited generalizability to unenrolled personnel), registries can be used to generate hypotheses for further evaluation. That said, it is unlikely that any amount of environmental sampling will be sufficient to completely characterize environmental health risks and alleviate all future health concerns. Awareness, assessment, documentation, and early risk communication may help reassure those deploying, whom we are obligated to protect. In order to provide meaningful risk communication, we must know how the collected information will be used to assess risk, and how to clearly communicate it to those who have the right to know.

REFERENCES

1. Presidential Advisory Committee on Gulf War Veterans' Illnesses. Special Report. Washington DC: US Government Printing Office; December 1996. Available at: <http://www.gulfink.osd.mil/gwvi/toc-f.html>. Accessed March 23, 2016.
2. Gray GC, Hawksworth AW, Smith TC, Kang HK, Knoke JD, Gackstetter GD. Gulf War Veterans' health registries. Who is most likely to seek evaluation?. *Am J Epidemiol.* 1998;148(4):343-349.
3. Committee on the DoD Persian Gulf War Syndrome Comprehensive Clinical Evaluation Program. *Evaluation of the U.S. Department of Defense Persian Gulf Syndrome Comprehensive Clinical Evaluation Program.* Washington, DC: National Academies Press; 1996. Available at: <http://www.nap.edu/read/9057/chapter/1>. Accessed March 23, 2016.
4. Committee to Review the Health Consequences of Service During the Persian Gulf War Medical Follow-up Agency. *Health Consequences of Service During the Persian Gulf War: Recommendations for Research and Information Systems.* Washington, DC: National Academies Press; 1996. Available at: <http://www.nap.edu/read/5272/chapter/1>. Accessed March 23, 2016.
5. US General Accounting Office. *Gulf War Illnesses: Improved Monitoring of Clinical Progress and Reexamination of Research Emphasis are Needed.* Washington, DC: US Government Accountability Office; June 23, 1997. Report GAO/NSAID-97-163. Available at: <http://www.gao.gov/assets/230/224299.pdf>. Accessed March 23, 2016.
6. Institute of Medicine. *Protecting Those Who Serve: Strategies to Protect the Health of Deployed U.S. Forces.* Washington, DC: National Academies Press; 2000:47. Available at: <http://www.nap.edu/read/9976/chapter/8#47>. Accessed March 23, 2016.
7. Executive Office of the President. *A National Obligation –Planning for Health Preparedness for and Readjustment of the Military, Veterans, and Their Families after Future Deployments.* Washington, DC: Executive Office Presidential Review Directive 5; August 1998:8,19. Available at: <http://clinton5.nara.gov/textonly/WH/EOP/OSTP/NSTC/html/directive5.html>. Accessed April 1, 2016.
8. US Army Public Health Command. Technical Guide 230: *Environmental Health Risk Assessment and Chemical Exposure Guidelines for Deployed Military Personnel.* Aberdeen Proving Ground, MD: US Army Public Health Center (Provisional). 2013. Available at: <https://phc.amedd.army.mil/PHC%20Resource%20Library/TG230.pdf>. Accessed March 23, 2016.
9. Weese CB, Abraham JH. Potential health implications associated with particulate matter in deployed settings in Southwest Asia. *Inhal Toxicol.* 2009;21:291-296.
10. Abraham JH, Baird CP. A case-crossover study of ambient particulate matter and cardiovascular and respiratory medical encounters among US military personnel deployed to Southwest Asia. *J Occup Environ Med.* 2012;54(6):733-739.

11. Abraham JH, DeBakey SF, Reid L, Zhou J, Baird CP. Does Deployment to Iraq and Afghanistan affect respiratory health of US military personnel?. *J Occup Environ Med*. 2012;54(6):740-745.
12. National Research Council. *Review of Department of Defense Enhanced Particulate Matter Surveillance Program Report*. Washington, DC: National Academies Press; 2010. Available at: <http://www.nap.edu/catalog/12911/review-of-the-department-of-defense-enhanced-particulate-matter-surveillance-program-report>. Accessed March 23, 2016.
13. Baird CP. Respiratory disease and deployment: What do we know? What do we think?. *US Army Med Dep J*. July-September 2011:80-86.
14. Abraham JH, Clark LL, Sharkey JM, Baird CP. Trends in rates of chronic obstructive respiratory conditions among US military personnel 2001-2013. *US Army Med Dep J*. July-September 2014:33-43.
15. Baird CP, DeBakey S, Reid L, Hauschild VD, Petrucci B, Abraham JH. Respiratory health status of US Army personnel potentially exposed to smoke from 2003 Al-Mishraq sulfur plant fire. *J Occup Environ Med*. 2012;54(6):717-723.
16. Armed Forces Health Surveillance Center. *Epidemiological Studies of Health Outcomes Among Troops Deployed to Burn Pit Sites*. Silver Spring, MD: Armed Forces Health Surveillance Center; 2010. Available at: http://fhp.osd.mil/pdfs/100604_FINAL_Burn_Pit_Epi_Studies.pdf. Accessed March 23, 2016.
17. Sharkey JM, Abraham JH, Clark LL, Rohrbach P, Ludwig S, Hu Z, Baird CP. Postdeployment respiratory health care encounters following deployment to Kabul, Afghanistan: a retrospective cohort study. *Mil Med*. 2016;181(3):265-271.
18. Baird CP, Harkins DK, eds. *Airborne Hazards Related to Deployment*. Fort Sam Houston, TX: Borden Institute; 2015.
19. Vietas AJ, Taylor G, Rush V, Deck A. *Screening Health Risk Assessment, Burn Pit Exposures, Balad Air Base, Iraq and Addendum Report*. Aberdeen Proving Ground, MD: US Army Center for Health Promotion and Preventive Medicine; May 2008. USACHPPM 47-MA-08PV-08; AFIOH IOHRS-BR-TR-2008- 0001. Available at: <http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA493142>. Accessed March 23, 2016.
20. Weese CB. Issues related to burn pits in deployed settings. *US Army Med Dep J*. April-June 2010:22-28.
21. Institute of Medicine. *Long-Term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan*. Washington DC: National Academies Press; 2011. Available at: <http://www.iom.edu/Reports/2011/Long-Term-Health-Consequences-of-Exposure-to-Burn-Pits-in-Iraq-and-Afghanistan.aspx>. Accessed March 23, 2016.
22. Weese CB. Review of the Institute of Medicine report: long-term health consequences of exposure to burn pits in Iraq and Afghanistan. *US Army Med Dep J*. July-September 2012:43-47.
23. Dignified Burial and Other Veterans' Benefits Improvements Act of 2012. Pub L No. 112-260, 126 stat 2417.
24. Somani S, Romano JA. *Chemical Warfare Agents: Toxicity at Low Levels*. Boca Raton, FL: CRC Press. 2001.
25. Chivers CJ. The secret casualties of Iraq's abandoned chemical weapons [archives]. *New York Times*. October 14, 2014. Available at: <http://www.nytimes.com/interactive/2014/10/14/world/middleeast/us-casualties-of-iraq-chemical-weapons.html>. Accessed March 23, 2016.
26. Under Secretary of the Army. Memorandum: Iraq Chemical Warfare Agent Exposure Review Implementation Guidance. Washington, DC: US Department of the Army; March 20, 2015. Available at: <https://assets.documentcloud.org/documents/1694786/chemguidelines.pdf>. Accessed March 23, 2016.

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Deployment-related Respiratory Issues

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ABSTRACT

Military deployment to Southwest Asia since 2003 in support of Operations Enduring Freedom/Iraqi Freedom/New Dawn has presented unique challenges from a pulmonary perspective. Various airborne hazards in the deployed environment include suspended geologic dusts, burn pit smoke, vehicle exhaust emissions, industrial air pollution, and isolated exposure incidents. These exposures may give rise to both acute respiratory symptoms and in some instances development of chronic lung disease. While increased respiratory symptoms during deployment are well documented, there is limited data on whether inhalation of airborne particulate matter is causally related to an increase in either common or unique pulmonary diseases. While disease processes such as acute eosinophilic pneumonia and exacerbation of preexisting asthma have been adequately documented, there is significant controversy surrounding the potential effects of deployment exposures and development of rare pulmonary disorders such as constrictive bronchiolitis. The role of smoking and related disorders has yet to be defined. This article presents the current evidence for deployment-related respiratory symptoms and ongoing Department of Defense studies. Further, it also provides general recommendations for evaluating pulmonary health in the deployed military population.

Among numerous reported health issues related to deployment, respiratory effects may occur due to the austere nature of theaters in Southwest Asia (SWA), primarily Iraq and Afghanistan.¹ Foremost of these are the potential airborne hazards due to higher levels of ambient particulate matter (PM) from suspended geologic dusts, frequent sand storms, industrial air pollution, and burn pit smoke from the incineration of military waste materials.² Numerous sources have implied a direct relationship between PM exposure during deployments with the development of serious and debilitating chronic pulmonary disease. Likewise, anecdotal cases of military personnel with respiratory symptoms are detailed in media articles suggesting there is a systemic problem with undiagnosed pulmonary disease in returning service members. The initial 2011 Institute of Medicine report, *Long-Term Health Consequences of Exposure to Burn Pits in Iraq and Afghanistan*³ concluded there was no established link between burn pit exposure and lung disease based on the available limited evidence.

The US Army Medical Department, Veterans Administration, and other research agencies within the Department of Defense (DoD) began actively pursuing scientific investigations into respiratory symptoms associated with deployment to better define the types, prevalence, and severity of both acute and chronic respiratory disease.⁴ Several important questions have been raised about airborne hazards, in particular burn pit smoke, and other environmental exposures during deployment:

- What is the current scientific evidence linking chronic lung disease related to military deployment?
- What are the current investigations into deployment-related respiratory disease?
- How should the clinical evaluation of the postdeployment service member with respiratory symptoms proceed?
- What is the role of increased smoking?
- Are there any specific approaches to help potential mitigate development of chronic lung disease by identifying susceptible individuals or use of personal protective equipment?

RESPIRATORY SYMPTOMS

There are reported increases in respiratory symptoms such as cough and dyspnea during deployment dating back to Operations Desert Shield/Storm. From initial reports on the health effects of the Kuwait oil fires of 1991 among US troops, surveys by Army investigators found increases in reported symptoms of upper respiratory tract irritation, dyspnea, and cough associated with proximity to these fires. Further survey research in a cohort of 1,560 veterans based on oil-fire proximity 5 years after the First Gulf War could not find a correlation in self-reported symptoms of asthma and bronchitis and modeled proximity exposures.⁵ Long-term respiratory outcomes 10 years postdeployment demonstrated no differences in pulmonary function testing (PFT) in a deployed First Gulf War cohort.⁶ More recently, initial

surveys from Operations Iraqi Freedom/Enduring Freedom (OIF/OEF) of 15,000 redeploying military personnel estimated that 69.1% reported experiencing respiratory illnesses, of which 17% required medical care.⁷ The Millennium Cohort Study is an ongoing Naval Health Research Center survey designed to evaluate the long-term health effects of military service members. Initial data from the baseline and follow-up surveys of 46,077 military personnel (10,753 deployed) found higher rates of newly reported respiratory symptoms in deployed compared to nondeployed personnel (14% vs 10%), although similar rates of chronic bronchitis/emphysema (1% vs 1%) and asthma (1% vs 1%) were observed.⁸

Despite the increase in respiratory symptoms, short term respiratory health effects due to specific exposures have not been identified. Epidemiologic research conducted by the Army Public Health Command of the enhanced PM surveillance sites found no association with increased PM exposures and acute cardiorespiratory events requiring medical encounters.⁹ Further analysis was conducted by the Public Health Command to evaluate trends in rates of chronic lung diseases in the military population from 2001 through 2013. Investigators observed decreases in the rates of asthma and chronic bronchitis over the 13-year study period, while the reported rates of nonspecific bronchitis tended to drive the overall trends in chronic respiratory disease.¹⁰

LUNG DISEASE ASSOCIATED WITH DEPLOYMENT

Acute Eosinophilic Pneumonia

There is published evidence for a cluster of acute eosinophilic pneumonia (AEP) cases related to deployment in military personnel. Eighteen cases were initially reported from 2003 to 2004 among 183,000 military personnel deployed in or near Iraq.¹¹ Acute eosinophilic pneumonia is an unusual disease of unknown etiology characterized by acute illness, respiratory failure, bilateral pulmonary infiltrates, hypoxia, and predominant eosinophilia (25%) on bronchoalveolar lavage (BAL). New-onset smoking was a definite risk factor as all were active smokers with 78% reporting recent onset of smoking.¹¹ Continued collection of data from Landstuhl Regional Medical Center now shows there have been 44 diagnosed cases with an average BAL eosinophilia of $36.8\% \pm 20.9\%$. Ninety-three percent of the patients were smokers and 65% required mechanical ventilation.¹² Bronchoscopy to demonstrate pulmonary eosinophilia has become a primary intervention in evaluating hypoxia in evacuated patients due to the increased incidence of AEP in this population.

Asthma

Asthma remains a common finding in military personnel that may mirror the incidence in the general population. The extreme climate conditions in SWA along with high PM exposures due to dusts or burn pit smoke could contribute to poor asthma control with increased exacerbations. A survey of deploying Army personnel identified 5% of troops deployed to SWA reported a previous diagnosis of asthma.¹³ While the asthmatics had poor baseline control of symptoms, there were no differences compared to nonasthmatics as both groups reported increased respiratory symptoms. A review of 6,000 Veterans Administration medical records (based on ICD-9 diagnostic codes with limited PFT data) noted higher rates of “new-onset” asthma in deployed military personnel between 2004 and 2007 compared to non-deployed personnel (6.6% versus 4.3%).¹⁴ A review by DoD investigators on 400 asthmatics undergoing a formal medical fitness for duty evaluation could not establish a definitive relationship between the diagnosis of asthma and deployment. In reviewing patient records, the diagnosis was objectively confirmed by testing in only 78% of the patients. Fifty percent of the cohort never deployed, 25% were diagnosed predeployment, and 25% of the asthmatics were diagnosed postdeployment. There was inadequate data to determine if this was undiagnosed preexisting disease in the postdeployment group. No differences in PFTs or asthma severity were noted based on time of diagnosis or deployment history.¹⁵ Similar findings were identified in a cohort of patients with a diagnosis of chronic obstructive pulmonary disease.¹⁶

Constrictive Bronchiolitis

Constrictive bronchiolitis (CB) is a lung disease characterized by fixed airways obstruction and fibrosis of the distal airways or bronchioles, with extrinsic narrowing or obliteration of the bronchiolar lumen. It is associated with environmental and occupational inhalation exposures such as diacetyl and may follow exposure to nitrogen and sulfur dioxides. Spirometry typically shows airflow obstruction without postbronchodilator increase and high resolution computed tomography (HRCT) of the chest often shows heterogeneous air trapping most prominent on expiratory imaging, sometimes with areas of patchy ground glass opacities and scattered cylindrical bronchiectasis.¹⁷ In 2011, King et al¹⁸ reported on a case series of 80 previously deployed military personnel, 49 of whom underwent surgical lung biopsy which resulted in 73% of those so examined receiving a pathologic diagnosis of CB. The patients comprising the case series had varied deployment exposures; less than half

of the entire cohort had exposure to the 2003 sulfur fire in Mishraq, Iraq. No standardized evaluation was employed and most patients did not undergo a comprehensive evaluation to rule out common etiologies such as asthma prior to lung biopsy. Few patients met the established definition of CB as the majority had exertional dyspnea, normal PFTs without fixed obstruction, and normal high resolution CT imaging. The pathological findings of this study have not been validated. Furthermore, an epidemiologic comparison demonstrated no increase in postdeployment medical encounters among military personnel exposed to the 2003 sulfur fire compared to unexposed personnel.¹⁹ An ongoing review of lung biopsy reports (unpublished to date) by the Joint Pathology Center demonstrated few active duty military with small airways disease and no increase in deployed individuals compared to nondeployers (5.1% vs 5.6%).

THE STAMPEDE STUDIES

STAMPEDE I

After the development of the DoD Pulmonary Working Group in 2010, several research studies were initiated to better define types of respiratory disease identified immediately post deployment, utility of pre- and postdeployment spirometry, and types of respiratory disease associated with chronic respiratory symptoms. The initial “Study of Active Duty Military for Pulmonary Disease related to Environmental Deployment Exposure” (STAMPEDE) began recruiting in 2010 and enrolled 50 patients with new onset respiratory symptoms within 6 months after returning from deployment.²⁰ This prospective standardized evaluation included full PFTs, chest HRCT, methacholine challenge testing (MCT), and fiberoptic bronchoscopy with BAL. A large percentage (42%) remained undiagnosed including 12% with normal testing and an isolated increase in lavage neutrophils or lymphocytes. Twenty (40%) patients demonstrated some evidence of airway hyperreactivity (AHR) to include eight who met asthma criteria and two with findings secondary to gastroesophageal reflux. No patients were identified with diffuse parenchymal disease on the basis of HRCT imaging. Interestingly, a significant number (66%) of this cohort had documented underlying mental health and sleep disorders.²⁰

STAMPEDE II

STAMPEDE II is a recently completed prospective study using pre- and postdeployment spirometry and impulse oscillometry (IOS) to determine if there is an objective decrease in pulmonary function following deployment. The deploying population consisted of nearly

Table 1. STAMPEDE II Predeployment Spirometry Values.

	All	Not Deployed	Prior Deployed
N	1,693	809	884
FEV ₁ (% pred)	93.2 ± 12.4	92.7 ± 12.3	95.6 ± 12.7
FVC (% pred)	94.4 ± 11.7	93.6 ± 11.3	98.4 ± 12.8
FEV ₁ /FVC	81.1 ± 6.6	80.9 ± 6.5	82.2 ± 6.9
FEF ₂₅₋₇₅ (% pred)	94.0 ± 25.5	94.1 ± 25.3	93.5 ± 26.9
Reduced FEV ₁ /FVC	143 (13%)	122 (13.2%)	21 (11.7%)

FEV₁ indicates forced expiratory volume at one second.
 FVC indicates forced expiratory capacity.
 FEF₂₅₋₇₅ indicates mid-expiratory flow.

1,700 active duty Army, National Guard, and Reserve personnel deploying to SWA from Fort Hood, Texas. All participants completed a brief respiratory survey and completed both spirometry and IOS pre- and postdeployment. Analysis of predeployment findings noted a mean age of 32 years with a body mass index of 27 kg/m². Nearly 40% reported a smoking history and 6% reported a history of asthma or bronchodilator use. Mean spirometry values, presented in Table 1, reflect significant percentages of Soldiers with obstructive spirometry predeployment. These abnormalities did not correlate with asthma history, prior deployments, or reported symptoms.²¹ Initial analysis of postdeployment spirometry demonstrated increases in all spirometry values (both FEV₁ and FVC) irrespective of smoking history, reported symptoms, or PM exposures.²²

STAMPEDE III

STAMPEDE III is an ongoing comprehensive study of deployed military personnel with chronic pulmonary symptoms. All participants undergo a standardized evaluation to include full PFTs, allergy testing, chest imaging with HRCT, IOS, exhaled nitric oxide, MCT, exercise laryngoscopy, echocardiography, cardiopulmonary exercise testing (CPET), and bronchoscopy with BAL. Preliminary data analysis of the first 200 patients enrolled has identified an older population with a mean age of 37 years and a variety of comorbidities including obstructive sleep apnea. Diagnoses, the distribution of which is presented in the Figure, show a similar trend to the 2002 exertional dyspnea study with asthma, nonspecific AHR, and vocal cord dysfunction (VCD) as common findings.²³ Diffuse lung disease is very uncommon, but several individuals have been diagnosed with cardiac abnormalities and excessive dynamic airway collapse. The utility of CPET, HRCT, and BAL analysis has not yet been determined in this group of patients.

EVALUATION OF DEPLOYED MILITARY PERSONNEL

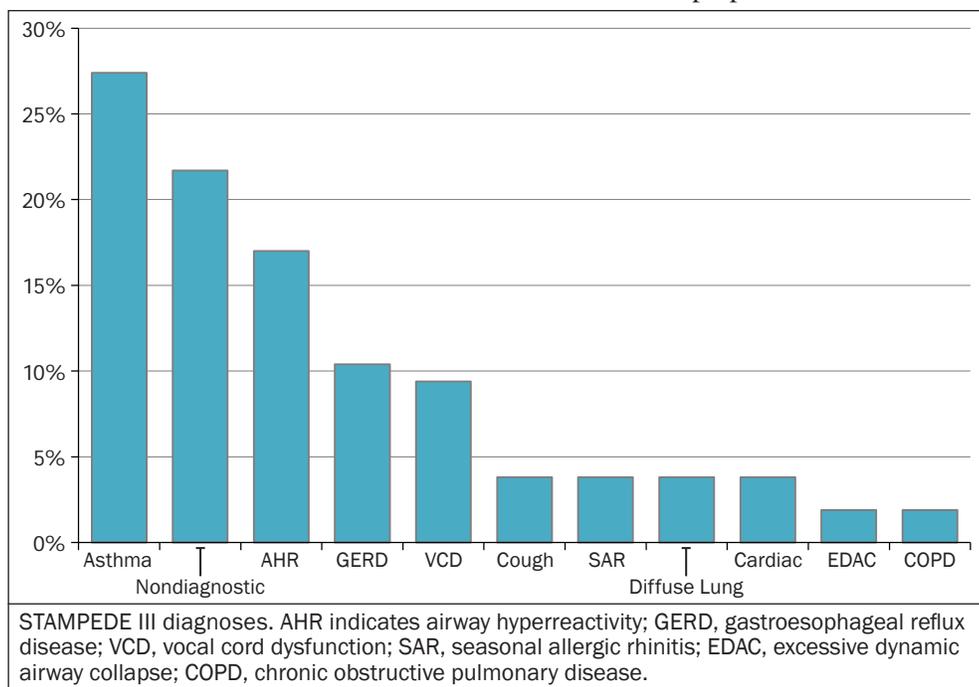
The evaluation of deployed military personnel can be challenging. Environmental exposures are ubiquitous and varied, and susceptible individuals may either develop new pulmonary symptoms or exacerbate preexisting disease. A comprehensive evaluation of exertional dyspnea in military personnel in 2002 by Morris et al²⁴ demonstrated the unique nature of their pulmonary disease. As expected, nearly half of the study population had either asthma or exercise-induced bronchospasm, while 10% had evidence of VCD. A more interesting finding was the 25% of evaluated patients with chronic dyspnea who had no abnormalities despite testing.²⁴ Most important in the initial pulmonary evaluation should be documentation of deployment exposures, relationship of deployment to symptoms, and any specific respiratory symptoms related to an acute exposure. At the primary care or initial evaluation, the minimum required tests should include at least baseline spirometry, bronchodilator response, and a chest radiograph. Referral for comprehensive testing at designated centers should be considered for unexplained symptoms (Table 2).²⁵ Further evaluation is primarily based on PFT and imaging findings.²⁵

After numerous meetings and review of the published literature since 2010, the Defense Health Board issued its statement on Deployment Pulmonary Health in February 2015 and made a series of recommendations based partially on the results of the STAMPEDE studies.¹ Several of the applicable clinical recommendations are summarized here:

1. Increase the number of pulmonary questions on pre- and postdeployment surveys and conduct routine analysis of responses.
2. Conduct predeployment spirometry in selected individuals if there is significant risk of airborne hazards due to location or required duties.
3. Develop a consistent and tiered approach to patients with unexplained postdeployment dyspnea.
4. Implement an enterprise-wide clinical registry of service members with postdeployment chronic pulmonary symptoms.
5. Conduct prospective cohort study of unexplained chronic dyspnea (including the cohort of service members who have undergone surgical lung biopsy) to determine longitudinal outcomes.
6. The DoD should continue research to develop respiratory personal protective equipment appropriate for field or combat use.

CONCLUSION

Presently, available data does not establish a specific link between the development of pulmonary disease and SWA deployment. However, specific causative factors (dust, burn pit smoke, etc) may have an effect on chronic respiratory symptoms of certain individuals. How best can the Army Medical Department prepare to mitigate potential effects of airborne hazard exposures? From a doctrinal standpoint, several changes should occur. First, the Army Public Health Center (Provisional) should be prepared to conduct routine testing of theater locations



and in particular, known locations with a higher propensity for developing respiratory disease (such as the 2003 Al-Mishraq sulfur fire or burn pit sites). This would include specific pulmonary evaluation of exposed individuals soon after the time of exposure. Second, the deploying force as a whole should be better screened for potential respiratory illness via predeployment questions on the predeployment health assessment. Those with chronic symptoms, known respiratory illness such as asthma, or inhaler use should undergo a basic pulmonary evaluation such as examination, spirometry,

1. Abnormal chest radiograph (interstitial changes, lung mass, hilar adenopathy, lung infiltrate, pleural effusion).
2. Restrictive indices on spirometry (both FEV ₁ and FVC < 70%).
3. Resting pulse oximetry below 95% or decrease of 4% with ambulation during a 6 minute walk test.
4. Need for bronchoprovocation testing to confirm asthma or exercise-induced bronchospasm.
5. Symptoms greater than 3 months with no response to treatment.
6. Prior treatment with oral steroids, hospitalization, or endotracheal intubation.
7. Unexplained dyspnea, cough and/or sputum production.
8. Symptomatic individuals with normal basic evaluation (spirometry and chest radiograph).

and chest radiograph. Third, those individuals with postdeployment respiratory symptoms (including those evacuated for respiratory illnesses) should be evaluated at designated DoD centers of excellence and be included on a clinical registry to determine long-term outcomes.

REFERENCES

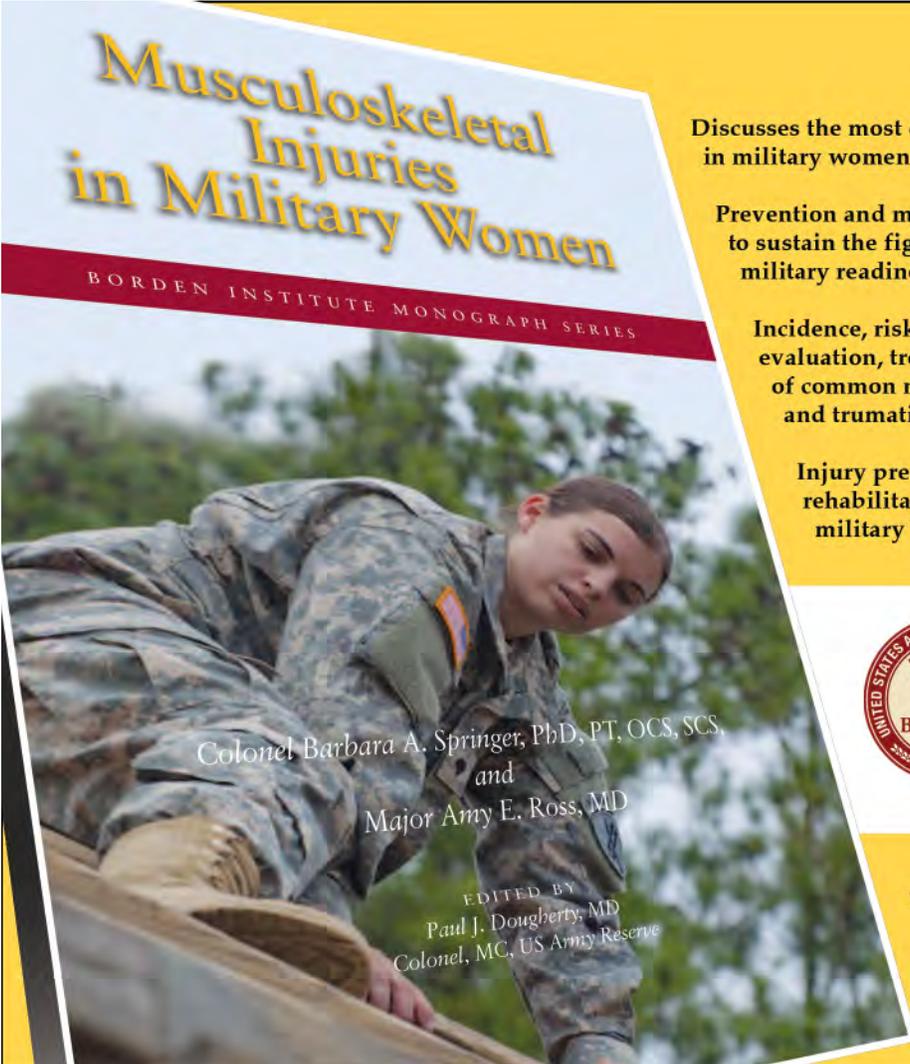
1. Defense Health Board. Memorandum: Deployment Pulmonary Health. Falls Church, VA: Office of the Assistant Secretary of Defense Health Affairs; February 11, 2015.
2. Weese CB, Abraham JH. Potential health implications associated with particulate matter exposure in deployed settings in Southwest Asia. *Inhal Toxicol.* 2009;21:291-296.
3. Institute of Medicine. Long-term health consequences of exposure to burn pits in Iraq and Afghanistan. Washington, DC: The National Academies Press, 2011. Available at: <http://www.iom.edu/Reports/2011/Long-Term-Health-Consequences-of-Exposure-to-Burn-Pits-in-Iraq-and-Afghanistan.aspx>. Accessed March 23, 2016.
4. Morris MJ, Zacher LL, Jackson DA. Investigating the respiratory health of deployed military personnel. *Mil Med.* 2011;176:1157-1161.
5. Lange JL, Schwartz DA, Doebbeling BN, Heller JM, Thorne PS. Exposures to the Kuwait oil fires and their association with asthma and bronchitis among Gulf War veterans. *Environ Health Perspect.* 2002;110:1141-1146.
6. Karlinsky JB, Blanchard M, Alpern R, Eisen SA, Kang H, Murphy FM, Reda DJ. Late prevalence of respiratory symptoms and pulmonary function abnormalities in Gulf War I veterans. *Arch Intern Med.* 2004;164(22):2488-2491.
7. Sanders JW, Putnam SD, Frankart C, et al. Impact of illness and non-combat injury during Operations Iraqi Freedom and Enduring Freedom (Afghanistan). *Am J Trop Med Hyg.* 2005;73(4):713-719.
8. Smith B, Wong CA, Smith TC, Boyko EJ, Gacksetter GS, Ryan MAK. Newly reported respiratory symptoms and conditions among military personnel deployed to Iraq and Afghanistan: a prospective population-based study. *Am J Epidemiol.* 2009;170:1433-1442.
9. Abraham JH, Baird CP. A case-crossover study of ambient particulate matter and cardiovascular and respiratory medical encounters among US military personnel deployed to Southwest Asia. *J Occup Environ Med.* 2012;54(6):733-739.
10. Abraham JH, Clark LL, Sharkey JM, Baird CP. Trends in rates of chronic obstructive respiratory conditions among US military personnel, 2001-2013. *US Army Med Dep J.* July-September 2014:33-43.
11. Shorr AF, Scoville SL, Cersovsky SB, et al. Acute eosinophilic pneumonia among US military personnel deployed in or near Iraq. *JAMA.* 2004;292:2997-3005.
12. Sine C, Allan P, Haynes R, Scoville S, Shuping E, Hultman A, Osborn E. Case series of 44 patients with idiopathic acute eosinophilic pneumonia in the deployed military setting. *Chest.* 2011;140(4 meeting abstracts):675A.
13. Roop SA, Niven AS, Calvin BE, Bader J, Zacher LL. The prevalence and impact of respiratory symptoms in asthmatics and non-asthmatics during deployment. *Mil Med.* 2007;172:1264-1269.
14. Szema AM, Peters MC, Weissinger KM, Gagliano CA, Chen JJ. New-onset asthma among Soldiers serving in Iraq and Afghanistan. *Allergy Asthma Proc.* 2010;31:67-71.
15. Delvecchio SP, Collen JF, Zacher LL, Morris MJ. The impact of combat deployment on asthma diagnosis and severity. *J Asthma.* 2015;52:363-369.
16. Matthews T, Abraham J, Zacher LL, Morris MJ. The impact of deployment on COPD in active duty military personnel. *Mil Med.* 2014;179:1273-1278.
17. Garg K, Lynch DA, Newell JD, King TE Jr. Proliferative and constrictive bronchiolitis: classification and radiologic features. *AJR Am J Roentgenol.* 1994;162(4):803-808.
18. King MS, Eisenberg R, Newman JH, et al. Constrictive bronchiolitis in Soldiers returning from Iraq and Afghanistan. *N Engl J Med.* 2011;365(3):222-230.
19. Baird CP, Debakey S, Reid L, Hauschild VD, Petrucci B, Abraham JH. Respiratory health status of US Army personnel potentially exposed to smoke from 2003 Al-Mishraq sulfur plant fire. *J Occup Environ Med.* 2012;54(6):717-723.

PUBLIC HEALTH CHALLENGES

20. Morris MJ, Dodson DW, Lucero PF, Haislip GD, Gallup RA, Nicholson KL, Zacher LL. Study of active duty military for pulmonary disease related to environmental dust exposure (STAMPEDE). *Am J Respir Crit Care Med.* 2014;190:77-84.
21. Skabelund A, Morris M. Baseline symptoms and pulmonary function of military personnel prior to deployment. *Chest.* 2013;144(4_meeting abstracts):480A.
22. Skabelund AJ, Morris MJ. The effect of deployment on the pulmonary function and respiratory symptoms of military personnel. *Am J Respir Crit Care Med.* 2015:Abstract Issue;A2577.
23. Morris M, Skabelund A, Haislip G, Lucero P. Comprehensive evaluation of military personnel with post-deployment respiratory symptoms. *Chest.* 2014;145(suppl 3):568A.
24. Morris MJ, Grbach VX, Deal LE, Boyd SY, Johnson JE, Morgan JA. Evaluation of exertional dyspnea in the active duty patient: the diagnostic approach and the utility of clinical testing. *Mil Med.* 2002;167:281-288.
25. Morris MJ, Negrescu C, Bell DG, Tinklepaugh CN. Discussion summary: basic diagnosis and workup of symptomatic individuals. In: Baird CP, Harkins DK, eds. *Airborne Hazards Related to Deployment.* Fort Sam Houston, TX: Borden Institute; 2015:121-130.

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Impact of North Atlantic Treaty Organization Policies and Procedures on Combined Medical Operations: Food and Water Safety and Veterinary Support

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ABSTRACT

Effective multilateral military operations such as those conducted by the North Atlantic Treaty Organization (NATO) require close cooperation and standardization between member nations to ensure interoperability. Failure to standardize policies, procedures, and doctrine prior to the commencement of military operations will result in critical interoperability gaps, which jeopardize the health of NATO forces and mission success. To prevent these gaps from occurring, US forces must be actively involved with NATO standardization efforts such as the Committee of the Chiefs of Medical Services to ensure US interests are properly represented when NATO standards are developed and US doctrine and procedures will meet the established NATO requirements.

Although few individuals questioned the importance of North Atlantic Treaty Organization (NATO) during the height of the Soviet Union's power and the Cold War, some wondered about the relevance of NATO after the collapse of the Soviet Union and its power over its Eastern European satellite countries. The Warsaw Pact's dissolution in 1991, however, has not reduced the need for military cooperation among NATO nations. Instead, NATO has grown to include over a half-dozen new members since 1991, and in 1994, NATO launched its Partnership for Peace program to foster trust and cooperation among European states.¹ This cooperation has supported numerous multilateral military operations including the Bosnian air campaign, the peacekeeping force in Serbia and Kosovo, the Afghanistan security mission, earthquake relief in Pakistan, and the counterpiracy mission in the Indian Ocean.² These recent examples highlight the transition in the past 2 decades from unilateral operations to multinational efforts, and underscore the increasing importance of effective and efficient multinational operations within NATO (28 nations) and its cooperative security initiatives such as Partnership for Peace (22 nations), Mediterranean Dialogue (7 nations), and Istanbul Cooperation Initiative (4 nations).³ Indeed, military reductions in many NATO countries and in the United States may make unilateral action virtually impossible, especially if the operation endures for an extended period of time.

Unlike Cold War plans, which often divided the area of operations into sectors where an individual nation operated independently, current operations often require partner nations to combine functions from many

countries to provide one required capability. For example, one nation provides hospital holding beds, another provides laboratory support, and a third provides surgical care, resulting in a defined medical capability. This type of "plug and play" combined operations requires well-defined roles of support and procedures (ie, interoperability) to ensure no capability gaps exist. Failure to develop interoperability standardization parameters prior to deployments leads to the initial identification of these gaps during combat operations (rather than during predeployment), which jeopardizes the health of service members and successful completion of operational missions. One example, described below, of this lack of early synchronization between NATO partners during Operation Enduring Freedom and Operation Freedom's Sentinel greatly elevated the food protection risk to coalition forces in Afghanistan.

COALITION FOOD SERVICE ESTABLISHMENTS IN AFGHANISTAN IN 2014

In December 2014, the United States assumed NATO food protection responsibilities in the Transitional Advisory and Assist Command-Central (Kabul). Simultaneously, Turkey replaced France as the Base Operations Support Integrator authority for the Hamid Karzai International Airport (HKIA) multinational force. Separate dining facilities (DFACs) operated by Turkey, NATO, and the United States were open on HKIA, serving coalition forces from all nations. Another DFAC, operated by NATO, served all coalition forces at Resolute Support Headquarters (RS HQ), the other major forward operating base in Kabul.

Initial inspections of food service establishments by US Veterinary Service and Preventive Medicine personnel revealed critical deficiencies, the most serious of which was the use of unapproved sources for potentially hazardous food items. The US policy, which is consistent with the NATO Food Protection Standardization Agreement (STANAG), requires Veterinary Service personnel to audit food processors to help ensure subsistence is safe and free of accidental and intentional contaminants.⁴ The Turkish DFAC at HKIA received most of their food from unapproved sources (ie, not audited in accordance with US or NATO standards) in Turkey, but they also procured some dairy products from local Afghan sources. Likewise, the NATO contracted DFAC at the RS HQ compound did not use NATO recognized approved sources, and inspections were not coordinated using a common standard. Similarly, many of the retail food vendors on both HKIA and RS HQ did not use approved sources (eg, dairy products, raw meat, eggs, bottled water, and ice were procured from local Afghan markets or other local sources). The interim solution to address the immediate risk was to temporarily restrict the Turkish DFAC to only Turkish personnel until they came into compliance with applicable NATO STANAGs, and to ensure that HKIA and RS HQ food concessionaires stopped using local Afghan sources. Personnel of the US Army Veterinary Service addressed the RS HQ DFAC contractual issues as described below.

The first effort to bridge this gap in 2003 was the development and ratification of a STANAG⁴ by the Food and Water Safety and Veterinary Support panel (FWSVS). This STANAG identified the requirements for approving food establishments wishing to sell to NATO. Later, the FWSVS learned that the original DFAC that was contracted by the NATO Maintenance and Supply Agency (now NATO Support Agency (NSPA)) did not require approved food sources. A review of the process revealed that NSPA had invited the United States to participate in the contract proposal meeting, but the logistician did not attend and did not consult the US Army Veterinary Services for food protection advice. Consequently, another country that attended the meeting provided their national food safety regulation as a template. Unfortunately, no provisions existed in the original contract for approved food sources or for DFAC inspections by any of the coalition nations. Although there was a separate NATO contract to address quality assurance at the DFAC, there was no procedure to harmonize inspection criteria by participating nations. Consequently, inspectors from various nations were inspecting the DFAC using their own national standards, which varied from country to country.

When these gaps were discovered, the US Army Veterinary Service delegate to the FWSVS worked closely

with other NATO countries to address the issues. Delegates from Norway, Belgium, and the US (at that time, former, current and future chairs of the FWSVS, respectively) visited NSPA leadership in 2010 to discuss food protection concerns. The NSPA was happy to discuss these issues and to work toward solutions that would be agreeable to the wider NATO community. The subsequent NSPA dining facility contract referenced applicable NATO STANAGs (approved food sources, food safety and defense, DFAC inspections, and bottled water requirements) which largely mirrored US regulations.^{5,6}

Unfortunately, in 2014 Allied Joint Force Command (JFC) Brunssum, Netherlands, did not contract with the NSPA, which had food safety experts aware of NATO food protection STANAGs, to draft or coordinate the food service contract for the DFAC at RS HQ in Kabul. Many of the initial gaps (eg, unapproved food sources, no unified national DFAC inspection criteria, failure to reference applicable STANAGs) and some new gaps appeared in the new contract for RS HQ, which was implemented at the end of 2014.

Because of the previous work of FWSVS to harmonize NATO procedures, the Chair of the FWSVS (US) was able to work more effectively with Allied JFC to modify their initial contract using existing STANAGs (ie, food protection, potable water). During this process, NATO JFC explained that although their contracting regulations allow best value considerations, this DFAC contract was awarded to the cheapest bidder (ie, lowest price/technically acceptable). Without best value considerations, the process is to develop and offer the contract requirements. Any contractor that can fulfill the requirements may be awarded the contract, based solely on price. In contrast, “best value” criteria allow the contracting officer to consider other variables, including, but not limited to, price. This distinct difference between best value and lowest price contracting principles underscores the importance of food protection expertise involvement in NATO contract development. The involvement of food protection expertise in contract development is also critical to ensure applicable NATO STANAGs are implemented by the multitude of involved agencies in the coalition defense contracting network.

The risks associated with multinational operations are greatest at the beginning and at the end of operations. During the peak sustainment of operations, when troop numbers are high and logistics processes are well established, many nations tend to provide their own support functions (medical, logistics, etc.). However, during initial entry and retrograde, nations tend to rely on whoever is there. For instance, most of the US-operated DFACs in Afghanistan have closed. The only establishment feeding US troops at RS HQ is the NATO JFC

contracted DFAC; at HKIA, most of the remaining DFACs are nationally operated.

Because of existing and appropriate NATO STANAGS, US Army Veterinary Service personnel were able to work with the RS HQ surgeon's cell to redraft the theater food protection policies to incorporate NATO standards, including provisions for approved sources and DFAC food protection standards that were more consistent with the broader community of participating nations.

WAY AHEAD FOR THE UNITED STATES: POTENTIAL ASPECTS OF DOTMLPF* TO BE ADDRESSED

For the United States to be effective during NATO operations, it must be fully engaged in NATO policy, planning, and procedure development. Medical standardization within NATO falls under the auspices of the Committee of the Chiefs of Medical Services (COMEDS). The US Joint Staff Surgeon typically represents the specific service Surgeons General at COMEDS meetings, which sets the strategic vision and objectives and directs and monitors the work of the subordinate (working groups and panels) activities. The working groups and panels are the committees where most of the policies and procedures are written and where the fierce work of standardization occurs. In order to ensure US and NATO procedures are integrated, the United States must be deeply engaged with these committees. Unfortunately, this is where the United States has failed to participate effectively on many occasions in the past.

Ensuring the proper assignment of personnel is critical for US success. While there have been instances where the United States has failed to send a representative to the committee meetings, the more common practice has been inclusion of personnel based simply on assignment to the European theater. This leads to the frequent rotation of US representatives due to reassignment, leaving the new representative little time to gain an understanding of NATO procedures or the ongoing work of the committee. This legacy has limited the US potential to make meaningful contributions to the groups and has not served US or NATO interests.

Instead of rotating representatives every 2-3 years based on their geographic assignment, the United States should select representatives who can serve longer terms (ie, 5 years or more). This will ensure representatives are knowledgeable on current NATO standardization efforts so US and NATO policies, procedures, and doctrine can be harmonized to the greatest extent possible. Importantly, travel funding for the representatives should be programmed by the organization primarily responsible for that function to ensure personnel are properly resourced. Failure to centralize funding jeopardizes

*Doctrine, organization, training, material, leadership, personnel, facilities

US interests; individual commands may not appreciate the importance of the mission and therefore not support the travel, or may not be aware of the risk associated with using rotating, local personnel.

Training on NATO organization and policies will also help improve US-NATO interoperability by increasing awareness among our leaders. Training should not be limited to entry level courses (ie, Basic Officer Leader Course) but rather a continual process. At a minimum, leaders should receive predeployment refresher training on NATO policies and procedures that could affect their mission. Only by increasing exposure and knowledge of coalition processes will the United States develop leaders that are prepared and agile enough to excel in multi-cultural operations.

REFERENCES

1. North Atlantic Treaty Organization. NATO timeline [internet]. Available at: www.nato.int/docu/posters/timeline-eng.pdf. Accessed September 27, 2015.
2. North Atlantic Treaty Organization. NATO operations and missions [internet]. Available at: http://www.nato.int/cps/en/natolive/topics_52060.htm. Accessed September 27, 2015.
3. North Atlantic Treaty Organization. NATO partners [internet]. Available at: <http://www.nato.int/cps/en/natolive/51288.htm>. Accessed September 27, 2015.
4. North Atlantic Treaty Organization Standardization Office. *STANAG 2541: Audit Principles and Risk Assessment of Food Processors and Suppliers Associated with Military Deployment*. NATO Standardization Office Website; 2010 [restricted access: <https://nso.nato.int/protected/>].
5. North Atlantic Treaty Organization Standardization Office. *STANAG 2556: Food Safety, Defense, and Production in Support of NATO Operations*. NATO Standardization Office Website; 2014 [restricted access: <https://nso.nato.int/protected/>].
6. North Atlantic Treaty Standardization Office. *STANAG 2136: Minimum Standards of Water Potability During Field Operations and in Emergency Situations*. NATO Standardization Office Website; 2015 [restricted access: <https://nso.nato.int/protected/>].

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Water for Warfighters in Iraq and Afghanistan: A Summary of Lessons Learned

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ABSTRACT

The Army is the Department of Defense executive agent for land-based field water supplies. The Army Corps of Engineers, Army Quartermaster Corps, and Army Medical Department coordinate to provide the necessary support to obtain, treat, disinfect, certify, distribute, and monitor drinking water during deployments. This collaboration is necessary to ensure that an adequate quantity of acceptable quality drinking water is available for deployed personnel at all base camps and in all operations. Important lessons were learned from the beginning of operations in Iraq in 2003 continuing throughout 2 wars. These included lessons about the employment and management of bottled water during deployments, the quality and potential usefulness of “wastewater” from the reverse osmosis water purifiers, the usefulness and acceptability of military packaged water, and our lack of preparedness to readily address the drinking water needs of small squad and platoon-sized operations lasting more than a few days. The lessons we learned have and will continue to enhance our ability to readily meet Warfighters’ requirements for that most critical of supplies—sustaining a supply of safe, aesthetically pleasing drinking water.

Safe drinking water is a critical component of Warfighter deployment health. Those who are inadequately hydrated or who incur gastrointestinal illness from drinking contaminated water are unable to perform their duties effectively, particularly in battle. Historically, when deployed Soldiers were responsible for obtaining their own drinking water, dehydration and waterborne diseases were common among the forces, and took their toll. In the modern Army, an abundant quantity of safe drinking water is provided to all personnel during deployments, courtesy of modern equipment and the combined efforts of Corps of Engineers, Quartermaster (QM), and Preventive Medicine (PM) personnel. The Corps of Engineers identifies and develops water sources, while the QM treats, disinfects, and, after PM personnel test and approve it, distributes the treated water. The QM’s *Water Planning Guide*¹ specifies the water volumes required for various activities during deployment, and *Technical Bulletin Medical 577*² contains field drinking water quality standards.

Following are 5 scenarios in which lessons in field water management that were learned over the past 12 years led to or will lead to improvements in the US military’s abilities to meet the water needs of deployed personnel.

ASSESSMENT OF CENTRAL COMMAND REVERSE OSMOSIS UNITS’ PREFILTER, PRODUCT, AND REJECT WATER

Current Army reverse osmosis water purification units (ROWPU) are pictured in Figure 1, and a simplified flow diagram is shown in Figure 2. After the source water is strained, it is variously prefiltered by cartridge and multimedia filters (600 gallons per hour (GPH) and

3000 GPH ROWPUs), membrane microfilters, or membrane ultrafilters. Prefiltration removes particulate and microbiological contaminants and prepares the water to be pumped at high pressure through the reverse osmosis (RO) vessels, which remove viruses, dissolved salts, and other contaminants from the water. Finally, calcium hypochlorite disinfectant is added to the product water, and it is ready for PM testing, distribution, and drinking. Only 40% to 70% of the influent water passes through the RO membranes and becomes product water, while dissolved and other contaminants removed by the membranes flow out of the system in the 30% to 60% of the water that is rejected as brine. In 2003, Army doctrine directed that reject water, or brine, should be disposed of as wastewater.

Water was scarce in the desert, and some Army and contract operators recognized brine as a valuable resource, disinfected it, and provided it to Warfighters to use for personal hygiene and sanitation in lieu of disposing of it. Due to some Warfighter complaints and at least one contractor who reported the actions, the Department of Defense Inspector General (IG) initiated an audit of potable and nonpotable water in Iraq in September 2006, with the technical support of the US Army Center for Health Promotion and Preventive Medicine (CHPPM).*

Raw, pretreated, and reject water qualities from 6 different Army and contractor-operated water treatment operations were evaluated by CHPPM over a 6-month period in Iraq. Depending on the quality of the source water,

*CHPPM has been disestablished and its mission assumed by the Army Public Health Center (Provisional).

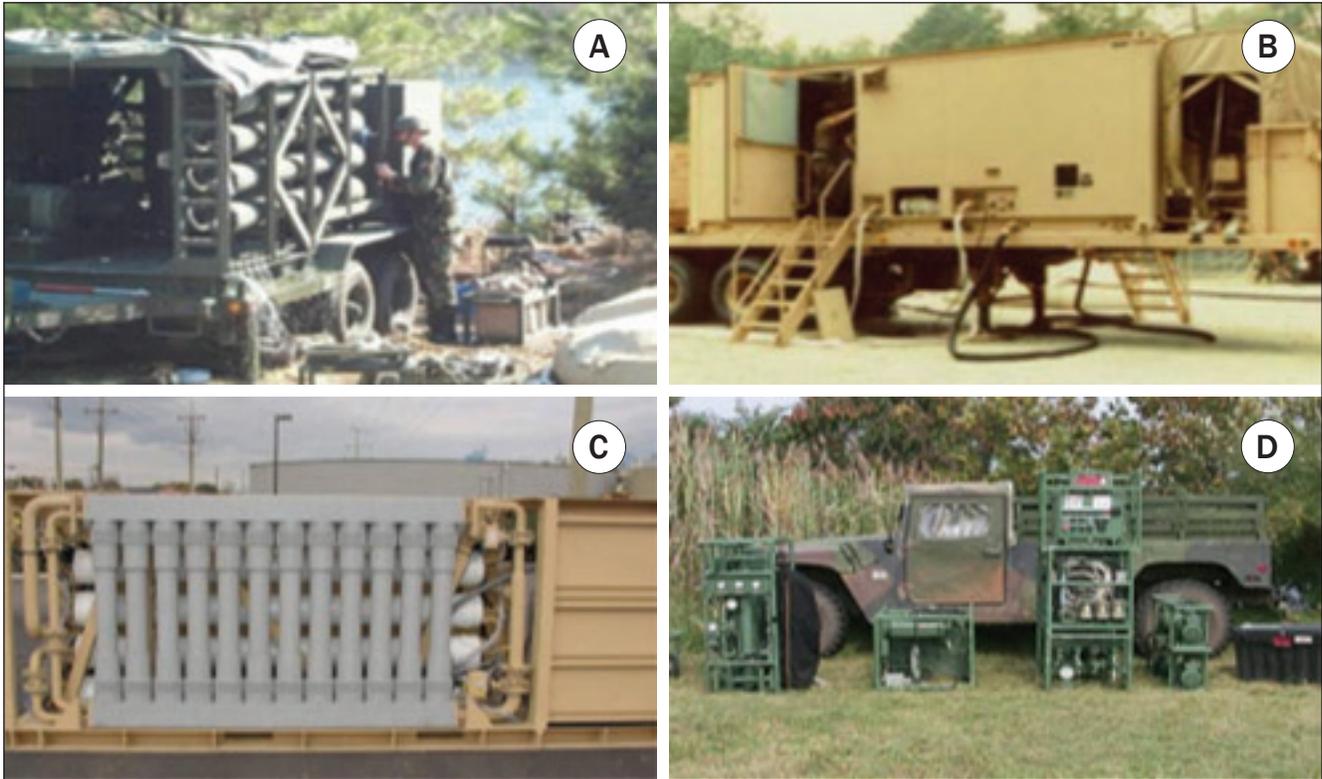


Figure 1. US Army reverse osmosis water purification equipment:
 A. 600 GPH ROWPU B. 3000 GPH ROWPU C. Tactical water purification system D. Lightweight water purifier

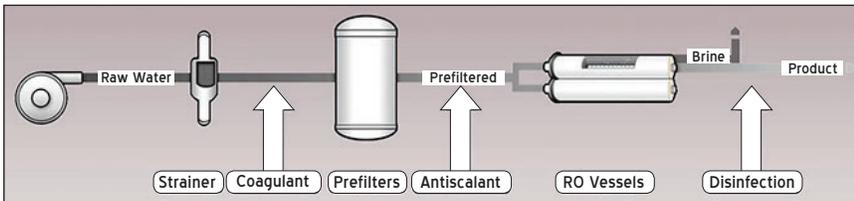


Figure 2. General schematic of water flow through a typical Army reverse osmosis water treatment unit.

Lesson learned: depending on the source water quality, all water streams produced by military RO purification equipment could be useful after disinfection, if the use is supported by verification testing and comprehensive monitoring.

USE OF BOTTLED WATER DURING DEPLOYMENTS

the pretreated water in many cases met field drinking water standards and could have been disinfected and consumed (avoiding the 30% to 60% loss in volume resulting from RO filtration). Even the RO reject water was in some cases superior in quality to the source water, and could have been chlorinated and used in ablu-tion systems with negligible health risk.

The IG report found that some units were not performing all required quality control tests, and that water suppliers exposed US forces to unmonitored and potentially unsafe water. The report also found that there was no way to determine whether water provided by the contractor and military water purification units caused disease, and that contractors and military units responsible for water operations must always ensure that water provided to the forces meets all established standards.³

Prior to 2003, bottled water was to be provided only during the early stages of deployments until military water supplies could be established and bulk water could be distributed using unit water trailers. However, in 2003, some National Guard units deployed to Kuwait expecting to receive a continuous and unlimited supply of bottled water, and left their unit water trailers in Kuwait as they moved forward. Subsequently, the unit commanders complained that the QM had unnecessarily rationed their bottled water supplies. Bulk water points had been established, but those units had no way to pick up bulk water, since they no longer had their water trailers. Although QM leadership reacted quickly to procure additional bottled water, the bottles that they had with them had to be rationed for a short period of time until sufficient quantities could be obtained. This change in bottled water policy—drinking it throughout

PUBLIC HEALTH CHALLENGES



Figure 3. Examples of large and small, indoor and outdoor bottled water storage.

deployments—increased the cost of drinking water and strained transportation assets, requiring as much as 50% to 60% of available vehicles to haul bottled water versus ammunition, equipment, repair parts, and other supplies.

Lesson learned: if leaders continue to support its use, we must plan and prepare to provide bottled water for drinking throughout deployments, and to use bulk field water for other purposes.

EVOLUTION IN PM BOTTLED WATER SURVEILLANCE

To meet the increased demand for bottled water, it was procured from sources in the United States as well as from nations surrounding the area of operations (AO). To sell water to the military, bottled water producers' facilities, operations, and water quality had to be audited and approved by US Army Veterinary Service (VS) personnel, and added to the list of approved food sources.⁴ While these requirements ensured that the bottled water was safe at the production sources, PM leaders, concerned for possible contamination during transit and in storage locations, established robust bottled water quality monitoring requirements. An "All Army Activities" notification* was issued that required PM to inspect and test 10 bottles from every production lot when it entered the AO, and at 30-day intervals at every storage location in the AO. This requirement became a nearly impossible task for PM units. It was not clear what constituted a "lot," and bottles were stored in huge quantities in warehouses and storage yards, and in small quantities at innumerable locations on facilities throughout the AO as shown in Figure 3, all of which required periodic inspections. Inspections and testing were time consuming, and they added no apparent value over the duration of the deployments.

Lesson learned: the safety of bottled water was adequately protected by source and periodic inspections performed by VS personnel and storage management by QM personnel. The new policy is that PM personnel are only required to respond to requests for bottled water testing when a need is identified.

*Internal military document not readily accessible by the general public.

"THE GRAND EXPERIMENT" OF MILITARY PACKAGED WATER

Drinking primarily commercial bottled water throughout the deployment posed several problems. As much as 60% of transportation assets were used to deliver it. Truck driving was considered one of the most dangerous military occupational specialties, and there was concern that intentional contamination opportunities existed during transportation and storage. At one point, the fully burdened cost of bottled water, including fuel, convoy security, management, and storage costs, was estimated at more than \$25 per gallon.

The Marine Corps generated an operational needs statement for a mobile water packaging system that could be set up wherever an RO system was located. Anticipated benefits included that the water would be:

- ♦ produced by the Army, reducing procurement costs;
- ♦ packaged near its point of consumption, reducing transportation costs and risks;
- ♦ under the control of the Army at all times, reducing intentional contamination opportunities;
- ♦ and consumed shortly after production, reducing storage requirements.

Additionally, the mobile packaging system would allow the elimination of normally required chlorine residual levels, significantly improving the taste of the water—an important improvement.

Research Development and Engineering Command's Product Manager for Petroleum and Water Systems (PM-PAWS) purchased a Kärcher (Alfred Kärcher, GmbH and Co, Winnenden, Germany) mobile water bottling system (Figure 4) that could package 700 one-liter plastic bottles of water per hour. The PM-PAWS, Army Test and Evaluation Command, VS, and CHPPM jointly tested and evaluated the system at Aberdeen Proving Ground, MD, in Germany, and at Forward Operating Base Delta in Iraq, and determined its use was feasible. Detailed standing operating procedures were developed to ensure the packaged water would consistently meet the military field water standards in *Technical Bulletin Medical 577*.^{2(p35)} Seven systems were set up and operated at various locations in Afghanistan,

Blow molder, filler, capper, labeler in one transportable container.
Capacity of 700 bottles per hour.



Semiautomatic system,
reliable in field conditions

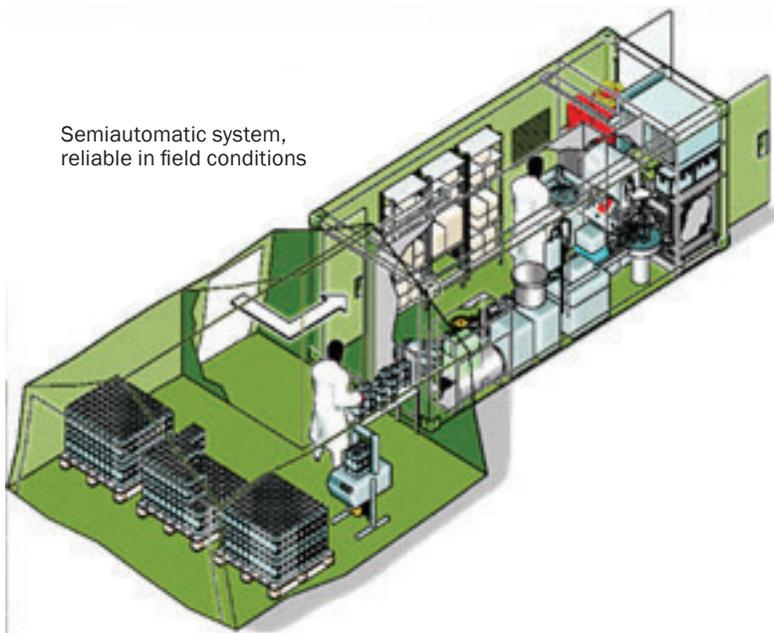


Figure 4. Kärcher WB 700 water bottling system.

all fed by contractor-operated RO water treatment systems. The RO-treated and disinfected water was passed through carbon filters to remove the chlorine residuals, and immediately packaged in one-liter bottles. The primary differences between the packaged water and commercial bottled water were the shape of the bottles and the brand names on the labels. Soldier acceptability was exceptional. Between August 15, 2010, and December 30, 2012, a period when all 7 systems were operational, more than 20 million bottles of water were produced for deployed personnel. The estimated cost was \$4 per gallon. With appreciable PM and VS oversight, the grand experiment was deemed a success.

Lesson learned: military packaged water is much less expensive, and is as safe and desirable as commercially bottled water during deployment operations.

DISTRIBUTED WATER OPERATIONS

Figure 5 illustrates the spectrum of field water requirements and the equipment available to meet those requirements. At one end of the spectrum, bulk water purification systems provide drinking water for large units. All of these systems require skilled operators and logistics support for maintenance and to move the treated water to the point of consumption, as well as PM personnel and equipment to test the quality of the water. At the other end of the spectrum, individual water purifiers (IWP) can supply microbiologically-safe water during emergencies and short-term missions. Preventive medicine personnel assist units with IWP device selection, based on the mission.

A capabilities gap exists for units performing small-unit operations lasting longer than a week. Operations at small forward operating bases and command outposts, and village stability operations complicate water supply issues as shown in Figure 6. Fielded water treatment systems that address the needs of these low-density locations do not currently exist. Bulk and bottled water transports to these locations are often targeted by enemy forces, and limited travel capabilities and high force protection issues often prevent PM from visiting to provide oversight of water quality.

The Army is working to develop systems and procedures that will better suit the needs of Soldiers in these operations, and

the use of commercial off-the-shelf (COTS) systems such as those shown in Figure 7 are one consideration. However, problems with their use include the lack of trained operators, the lack of logistical support for repair parts, and the lack of adequate water quality monitoring equipment and personnel trained to use it. Their use in small unit operations clearly increases health risk, and all members of the military field water community are engaged in dealing with these issues to enhance water capabilities for these operations.

Lesson learned: preventive medicine resources should be aggressively involved in all aspects of small unit COTS water purifier applications and work with combat developers to minimize the Warfighter health risk inherent in their use.

PUBLIC HEALTH CHALLENGES

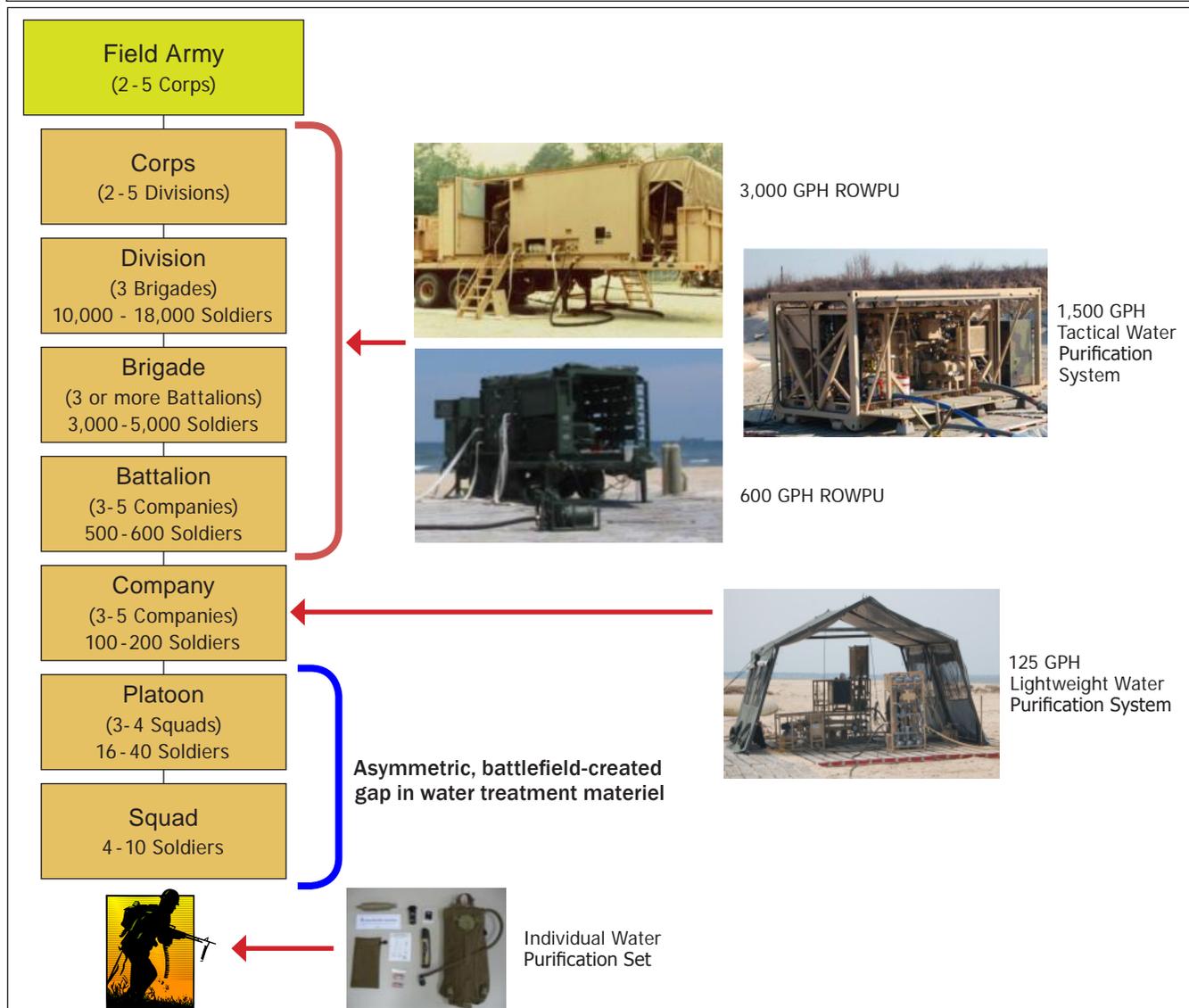


Figure 5. The spectrum of Army combatant command field water requirements and equipment available to meet them.

CONCLUSION

The availability of adequate quantities of acceptable quality drinking water is essential for deployed personnel to be effective across the spectrum of military operations. Preventive medicine, Corps of Engineers, and QM personnel overcame many challenges in Iraq and Afghanistan to ensure that availability at all levels of operations. Lessons were learned and changes were implemented to enhance all aspects of water treatment, delivery, testing, and monitoring. Continued Army modernization will necessitate concurrent evolution of field water supply practices and procedures to meet the changing needs of all deployed personnel and operations. Medical community participation in the application of the Doctrine, Organization, Training, Material, Leadership, Personnel, and Facilities problem-solving

construct to meet those needs and preserve the health of deployed personnel is imperative. In the final analysis, the Army's ultimate weapon does indeed run on water.

REFERENCES

1. US Army Combined Arms Support Command CASCOM, 25 November 2008, *Water Planning Guide*, Force Development Directorate, Fort Lee, VA Available at: [http://www.quartermaster.army.mil/pwd/publications/water/Water_Planning_Guide_rev_103008_dtd_Nov_08_\(5-09\).pdf](http://www.quartermaster.army.mil/pwd/publications/water/Water_Planning_Guide_rev_103008_dtd_Nov_08_(5-09).pdf).
2. *Technical Bulletin Medical 577: Sanitary Control and Surveillance of Field Water Supplies*. Washington, DC: Departments of the Army, Navy, and Air Force; May 2010. TB MED 577/NAVMED P50-10/AFMAN 48-138_IP. Available at: http://army-pubs.army.mil/med/DR_pubs/dr_a/pdf/tbmed577.pdf. Accessed March 30, 2016.



Figure 6. A shower, handwashing station, and a well, typical of water supply situations at village stability operation locations.

3. Deputy Inspector General for Auditing. *Inspector General Report No. D-2008-060: Audit of Potable and Nonpotable Water in Iraq*. Washington, DC: US Department of Defense; March 7, 2008. Available at: <http://www.dodig.mil/audit/reports/fy08/08-060.pdf>. Accessed March 30, 2016.
4. US Department of Defense. *Worldwide Directory of Sanitarily Approved Food Establishments for Armed Forces Procurement*. Aberdeen Proving Ground, MD: US Army Public Health Center (Provisional), 2016. Available at: <https://phc.amedd.army.mil/topics/foodwater/ca/Pages/DoDAprovedFoodSources.aspx>. Accessed March 30, 2016.



Figure 7. Examples of commercial off-the-shelf small unit water purification equipment.

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Surgical and Resuscitation Capabilities for the “Next War” Based on Lessons Learned From “This War”

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ABSTRACT

The Army gleaned many lessons regarding the provision of medical care to casualties during the past 14 years of combat. Using these lessons learned in the Joint Capabilities and Integration Development process and through the analysis of an integrated process action team, the Army recently approved 3 changes to medical organizations that are intended to provide trauma management farther forward on the battlefield. These changes include the substitution of an emergency medicine trained physician and emergency medicine physician assistant (PA) in lieu of a general medical officer and primary care PA within the brigade combat team; reorganization of the forward surgical team into a forward surgical and resuscitative team; and the modularization of the traditional 248 bed combat support hospital. The Army anticipates that these changes related to personnel, organizations, doctrine, and materiel will enable Army medicine to provide enhanced trauma management closer to the point of a combatant's injury. These modifications are projected to begin in fiscal year 2016.

Over the past 14 years at war, knowledge pertaining to casualty care has expanded exponentially. The lessons learned and strategic guidance such as “Army 2020 and Beyond”¹ call for a “modular, scalable, networked and flexible health service support force structure.” Additionally, the importance of expedited medical care on the battlefield was prioritized in 2009 by the Secretary of Defense mandate that injured service members receive treatment at a military medical facility within 60 minutes of a call, ie, “the golden hour.”² This requirement and strategic guidance caused a reevaluation of existing medical unit structure that led to 3 recent organizational changes in Army medicine. These approved changes were suggested after detailed analysis and recommendations that resulted from the work of several integrated process action teams (IPATs), each chartered specifically to study the organization.

The IPATs followed the process outlined by the Joint Capabilities Integration Development System. In order to address medical capability gaps identified during the ongoing war, IPATs were composed of subject matter experts including, but not limited to clinicians; senior officers and noncommissioned officers; experts in doctrine, organizational, personnel and equipment management; and representatives from the Center of Army Lessons Learned. The IPAT conducted a thorough analysis

in an effort to determine the requirements to meet mission demands, current capabilities, the gaps in the ability to meet these demands, and a myriad of potential solutions to fill those gaps.

All 3 changes discussed in this article are aimed at providing the casualty an enhanced level of trauma management as close to the point of injury as possible. The first change is a personnel substitution that assigns a trained emergency medicine clinician in place of a general medical officer in the brigade support medical company (BSMC) treatment squad. The second modification is a force design update (FDU) of the forward surgical team (FST) resulting in a forward surgical and resuscitative team (FRST), which allows for 2 identical teams with the same capabilities to operate in different locations. The third change to be discussed is the FDU of the combat support hospital (CSH) that results in a more scalable and modular deployment of CSH assets to meet mission demands. These 3 changes will lead to more efficient deployment of medical assets to the point of need, bringing a higher level of care closer to the patient as opposed to bringing the patient to care. The Army projects that these modifications will begin taking place in fiscal year (FY) 2016 and will be complete by FY 2022, based on mission demands and available resourcing.

ADVANCED TRAUMA MANAGEMENT/DAMAGE CONTROL
RESUSCITATION TEAM IN THE BRIGADE COMBAT TEAM

At divisional level and below, the Army has lacked the ability to provide specialized advanced trauma management (ATM)/far-forward damage control resuscitation (DCR) at or near the point of injury to prevent deterioration and death in the urgent presurgical patient and reduce the number of deaths with potentially survivable wounds.³ There is a lack of specialized clinicians at Roles 1 and 2 who possess trauma management training and skill. Further confounding this problem is the inability of the assigned clinicians to receive and sustain the appropriate training relevant to current standards for trauma management.

It is recognized that advances in battlefield trauma care and the institution of the Tactical Combat Casualty Care guidelines have resulted in the saving of many lives from the point of injury through the continuum of care. Tourniquets, hemostatic dressings, nonprotein colloids, intraosseous access devices, and hypothermia prevention systems have contributed significantly to decreased morbidity and mortality; however, battlefield resuscitation of major hemorrhage remains a high priority. From a retrospective analysis, the majority of “potentially survivable” injuries resulting in death on the battlefield and after reaching a surgical facility are caused by hemorrhage. In a hemorrhage situation, “resuscitation” refers to the restoration of circulation after blood loss. Resuscitation is vital because restoration of blood volume and blood pressure are the main methods for preventing hemorrhagic shock. Hemorrhagic shock is a severe life-threatening condition which, if left untreated, will promote the dysfunction or complete failure of the vital organs, causing the patient to die. According to Joint Theater Trauma Registry data, over 21% of military casualties are in shock upon admission to the CSH or FST, and over 25% require a blood transfusion. In combat, hemorrhage is the cause in 85% of all such potentially survivable deaths. Other significant causes of death among potentially survivable casualties are central nervous system injury (ie, head, neck, spinal cord), airway compromise due to obstruction or injury, and multisystem organ failure related to shock and the lethal triad of hypothermia, coagulopathy, and acidosis. By projecting a higher capability of medical care such as ATM/DCR forward to the casualty, the subsequent enhancement of treatment of these injuries will improve the likelihood of stabilizing the casualty and potentially extend patient survival time before surgical intervention.

In 2015, Kotwal et al⁴ published data that supports the 2009 Secretary of Defense’s institution of the “golden hour” for patient care. There was a significantly lower

percentage killed in action among those casualties who received a blood transfusion (6.8% vs 51%; $P<.001$) and those who were transported to definitive care within the 60 minute requirement (25.7% vs 30.2%; $P<.01$). A recommendation was submitted in 2015 by the Advanced Trauma Management IPAT, endorsed by the Commanding General, AMEDD Center and School and Health Readiness Center of Excellence, through the US Army Training and Doctrine Command, and approved by the Department of the Army that provides standardized resuscitative teams capable of supporting forward DCR, comprised of specific key tasks performed by expert emergency medicine clinicians who are assigned organically for employment by commanders and medical planners within a brigade combat team.⁵

The approved solution to enhance the ATM/DCR capability calls for the substitution of the previously assigned area of concentration (AOC) 62B (field surgeon/general medical officer) and AOC 65D (primary care physician assistant) with AOC 62A (emergency medicine physician) and AOC 65DM2 (emergency medicine physician assistant) in one treatment squad within the BSMC. This change provides the brigade surgeon guidance and direction regarding the trauma system, and moves enhanced ATM/DCR capable teams closer to the point of injury to provide advanced trauma care. Enhanced ATM/DCR will be focused within the medical company that is organic to the brigade combat team.

FORWARD RESUSCITATIVE AND SURGICAL TEAM

The second change is based on an identified requirement to provide a standardized, rapidly deployable, modular, and scalable resuscitative and surgical team capable of supporting short (less than 72 hours) or extended (more than 72 hours) operations. The FST, originally envisioned and designed in the 1990s, was based on the then current operating concepts and standards of care. The doctrinal employment of these units required they remain intact in their 20-person configuration. When FST split-based operations were attempted during the current war, erosion in both capability and capacity occurred.^{6*}

The new FRST design is based on current lessons learned, enforcement of current policy, and input and mission support requirements from US Army Special Operations Command (SOCOM) and Forces Command commanders and medical planners/providers.^{2,6,7*} The opinions and experiences of clinical subject matter experts as well as former and current FST Chiefs were also weighed. These recommendations were made with

*R. Espinosa, 274th FST after action report, memorandum for the record; 2006. Internal military document not readily accessible by the general public.

DOCTRINE AND TRAINING PROGRAMS

consideration of future operating concepts and environments. Modifications to this team focused on the ability of the team to simultaneously operate in 2 locations with the team's organic personnel and equipment. Moving to a more modular force created a need for more flexible support elements. A more flexible design and revised surgical skill competencies are intended to meet the combatant commanders' need for independent operations while expanding damage control capabilities across the battlefield, especially closer to the point of injury.

An approved force design update of the forward surgical team resulted in the new FRST. The design update revised and streamlined the surgical procedure list into 8 specific damage control surgeries (DCS) the team could perform, while reorganizing the personnel in an effort to accommodate a balance of surgical skill sets during split-based operations. The emergence of DCR as an important adjunct to the forward surgical capability was recognized in the new design. This resulted in the addition of emergency physicians and emergency nursing personnel who will be able to focus on DCR interventions in the pre- and postoperative areas while the surgical teams perform DCS in the operating suites. Modelling and experimentation suggest a capability that combines DCS and DCR will increase both capability and throughput of the FRST vice a resuscitative and surgical capability employed by surgeons alone. The postresuscitative holding section of the FRST has been enhanced to include a more robust postresuscitation capability and skill set (Figure 1). At the request of SOCOM, a 6-man element was designed to provide short-term, mission-specific DCR/DCS in support of unconventional operations. Additionally, materiel

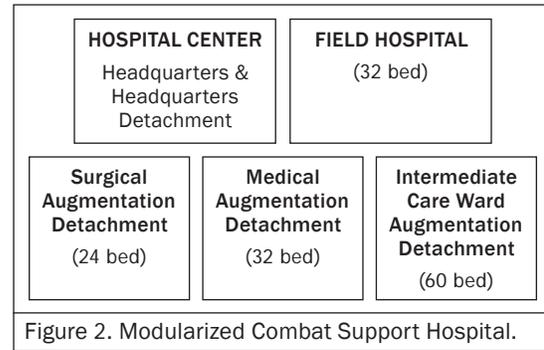


Figure 2. Modularized Combat Support Hospital.

additions including additional generators, information technology systems, and radios enable the FRST to conduct split-based operations without dependency upon or collocation with a Role 2 medical company.

COMBAT SUPPORT HOSPITAL

As previously indicated, a more modular combatant force creates a need for more flexible support elements. This includes a requirement for the CSH to be scaled and tailored to support unified land operations. After action reviews documented the inability of the traditional CSH to conduct split-based operations due to personnel and equipment limitations.* Through analysis and review of past operations, a CSH required augmentation in order to function in multiple locations simultaneously. In an effort to mitigate this capability gap, a FDU was submitted and approved. The redesigned unit is capable of

*Internal military documents not readily accessible by the general public:

Memorandum for the record: After Action Review for 86th Combat Support Hospital Operation Desert Eagle in Support of Operation New Dawn (Sep 2010-Sep 2011); 2011.
AMEDD Lessons Learned Observation Summary #933; July 28, 2010 [restricted access].

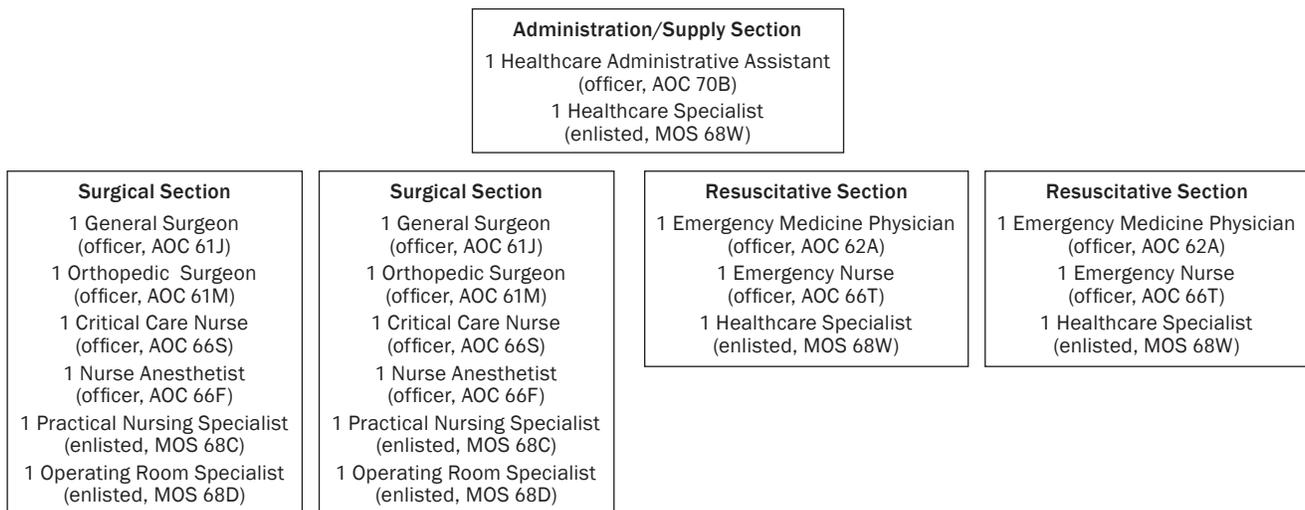


Figure 1. Organizational structure of the Forward Resuscitative and Surgical Team. Total manning: 13 officers, 7 enlisted.

modular deployment enabling it to conduct split-based operations and enhanced early entry healthcare. These capabilities were added by redesigning the single 248 bed CSH into 5 separate units that maintain the ability to be deployed independently as needed (Figure 2). The new design offers combatant commanders the ability to call for early entry trauma capabilities, but allows for the expansion of hospital based capabilities for enduring operations. Additionally, the redesign was intended to increase selective surgical and emergency medicine capabilities; increase intensive care capability; and integrate organic computer tomography (CT) scanners and microbiology lab capabilities into the unit.

CONCLUSION

The 3 changes discussed here demonstrate how lessons learned from the ongoing war have led to solutions in doctrine, personnel, organization, and materiel. Both the substitution of specialized providers at in the brigade support medical company and the reorganization of FST into the FSRT are intended to provide a higher level of ATM/DCR or DCR/DCS farther forward during operations. Additionally, the new FSRT and modularized CSH are enabled to conduct split-based operations and deploy assets as needed to support the mission. The materiel additions that include an organic CT scanner will further expand the capabilities of the CSH. As these solutions are implemented, there will be continuous review and analysis of their effectiveness.

REFERENCES

1. Combined Arms Support Command. Army 2020 and Beyond Sustainment White Paper. Fort Lee, VA: US Army Combined Arms Support Command; August 30, 2013. Available at: <http://www.cascom.army.mil/> [Sustainment White Paper link]. Accessed March 30, 2016.

2. Shanker T. Gates seeks to improve battlefield trauma care in Afghanistan. *New York Times*. January 27, 2009. Available at: http://www.nytimes.com/2009/01/28/washington/28military.html?_r=0. Accessed October 7, 2015.
3. Gerhardt RT, De Lorenzo RA, Oliver J, Holcomb JB, Pfaff JA. Out-of-hospital combat casualty care in the current war in Iraq. *Ann Emerg Med*. 2009;53:169-174.
4. Kotwal RS, Howard JT, Orman JA, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. *JAMA Surg*. 2016;151(1):15-24.
5. Gardiner H, Forslund M, Freel DA. Army DOT-mLPP-P Integrated Capabilities Recommendation (DICR) for Advanced Trauma Management/Damage Control Resuscitation (ATM/DCR). Joint Base San Antonio-Fort Sam Houston, TX: Advanced Trauma Management Integrated Process Action Team; 2015.
6. Patel TH, Wenner KA, Price SA, Weber MA, Leveridge A, McAtee SJ. A US Army forward surgical team's experience in Operation Iraqi Freedom. *J Trauma Acute Care Surg*. 2004;57:201-207.
7. Moore T. Memorandum: Extraction and Analysis on Medical Team, Forward Surgical (FST) Split-based Operations. Joint Base San Antonio-Fort Sam Houston, TX: Directorate for Combat and Doctrine Development, US Army Medical Department Center and School; 2014.

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**COMBAT CASUALTY CARE
LESSONS LEARNED FROM
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Predeployment Medical Training for Providers

MAJ Michael D. Holloway, SP, USA

ABSTRACT

Following the attacks of September 11, 2001, the United States became simultaneously engaged in military conflicts in 2 theaters of operation. At that time there was no organized program to train medical providers assigned to deployable Role 1 or Role 2 aid stations. To fill this gap, the Tactical Combat Medical Care (TCMC) course was developed and instituted at Fort Sam Houston, Texas, in 2004 to provide the training platform for providers in preparation for assignment to and deployment with combat units. The TCMC course has become the standard for prehospital wartime care training. All military healthcare providers (physicians, physician assistants, nurses, combat medics) requiring training to supplement their basic medical education and facility-based experiences are eligible to attend this course.

Military healthcare provider training programs primarily train their doctors, physician assistants, and nurse practitioners using civilian institutional training mechanisms. This consists of classroom lectures, skills training as well as hospital and clinic based practice. Providers in these environments have access to a support team of skilled nurses, technicians, laboratory, radiology, and pharmacy professionals. They work in controlled environments with a ready availability of a wide variety of surgical equipment sets and medical supplies. Most will continue to practice in these environments after graduation until they are called upon to deploy. While this is both appropriate for peacetime medicine and provides a strong foundation, for the deploying provider within the military system of healthcare, it does not go far enough. The medical equipment sets, conditions, and expectations of Tactical Combat Casualty Care (TC3) present a potentially steep learning curve. It is important that providers' first encounter with TC3 not be during deployment with a combat unit caring for actual casualties.

In the years leading up to the Global War on Terrorism, there was no structured course to prepare medical providers for assignment to Role 1 and Role 2 environments. With increased focus on the importance of tactical combat casualty care (TCMC) to reduce morbidity and mortality, the TCMC course was instituted.

COURSE HISTORY

In 2003, a number of physician assistants assigned to Fort Sam Houston, Texas, joined units scheduled for deployment to Iraq. They identified significant knowledge gaps related to deployment and prehospital care among providers, as well as lessons learned on the rapidly changing battlefields. To strengthen the preparation of recently commissioned and often newly graduated physician assistants likely to deploy shortly after arrival

at their units, the TCMC course was created as part of the corps-specific track of the Basic Officer Leadership Course. The goal was to familiarize them with the equipment used by their future unit and prepare them to provide medical care in an austere environment. The course was initially presented approximately 3 times per year. As the pace of deployments increased, it expanded up to 26 classes per year and opened its doors to deploying physicians, nurse practitioners, nurses, and senior noncommissioned officers in addition to the physician assistants for whom it was originally targeted.

The Tactical Combat Medical Care course served as the basis for creation, refinement, and improvement of other predeployment preparation courses for addressing additional echelons of care and experience levels of providers. These include the Brigade Combat Team Trauma Training course supporting combat medics, licensed practical nurses, and flight medics, the Military Transition Team course for Soldiers assigned to Military Transition Teams, and the Joint Forces Combat Trauma Management course for those assigned to combat support hospitals.

As of this writing, over 4,000 providers have received training in the TCMC course. During the peak training period, which operated until September 30, 2014, 2 classes were presented per month, 30 seats per class, with a total of 26 classes per year. However, although predeployment medical training has been a requirement since 2009 and class availability was greatly expanded, medical providers were still deployed without the mandated courses. Factors cited in the failure to attend training include appropriate window for course timing, short-notice deployment, availability of providers to leave other duties, command support, and the provider's perception of his or her own knowledge and competence.

CURRENT COURSE CONTENT

Currently, the TCMC course is a 5-day predeployment course conducted at Fort Sam Houston, Texas. There are 12 classes per year with funding for 10 students per class. The goal is to train providers at least 90 days prior to deployment, with priority given to those deploying to an austere or combat environment. The timing window is to help ensure that providers deploy with the most current knowledge and that it remains fresh in their minds. Nurses, senior medics, and flight paramedics are allowed to attend on a space available basis. The course is a predeployment requirement for all Role 1 and 2 providers per Headquarters, Department of the Army Execution Order 096-09HQDA* and US Forces-Afghanistan Fragmentary Order 14-067*.

In addition to preparation for battlefield medicine, the TCMC course also contributes to certification requirements by providing over 40 hours of Category 1 Continuous Medical Education (CME) credits. The course is comprised of didactic and hands-on training. There are 15½ hours of didactic covering TC3 based off the Committee on Tactical Combat Casualty Care guidelines and updates, Army Medical Department (AMEDD) lessons learned, feedback from the field, the Joint Theater Trauma Services weekly conference, and interaction with the Army Institute of Surgical Research.

The course also provides 27 hours of hands-on training to reinforce skills and muscle memory. Subjects demonstrated with hands-on training including rapid trauma assessment; fresh whole blood transfusion (the process of giving blood drawn recently (under 24 hours) and not separated into its components); pediatric trauma; intraosseous infusion devices currently in use such as the FAST 1 and EZ-IO; airway management including intubation and surgical cricothyroidotomy; thoracic trauma; junctional tourniquets; and emergency surgical skills performed in an environment simulating a deployed setting.

Providers will often be faced with providing healthcare outside the aid station as well as training and refining the skills of his or her medics. The TCMC course takes a crawl, walk, run method to training the providers on care under fire and tactical field care. This helps to ensure that they perform the right intervention at the right time in the continuum of care. The TCMC course places providers in situations similar to deployment to provide the most realistic training possible within the confines of available resources, and help them test their newly trained skills and assess their proficiency.

*Internal military documents not readily accessible by the general public.

As the battalion aid station is the primary treatment location for our deploying providers, TCMC also works to teach the team concept, each team member's role, and train them to be the team leader. This is done in a coached environment during the week, further helping to refine this skill. As the culminating event, the providers put their new or refined skills to action in a simulated deployed aid station, building confidence and competence.

One important area of training is trauma medication. In the hospital setting, providers prescribe medications and give instructions for their administration. The order itself is generally carried out by a licensed nurse; either a licensed practical nurse or registered nurse who has knowledge of drug preparation, dosing, administration, and side effects. In the deployed environment, the provider does not have that same trained staff. He or she is now taking on the responsibility not only for the order, but for the whole administration process. This can be a challenge. To ameliorate this, the TCMC course has a hands-on skills station for training and practicing common trauma medication preparation and administration. It also gives the provider a chance to ask any questions he or she may have in a safe environment with minimal risk.

Although providers are exposed to TC3 in the point of injury and Role 1 and Role 2 environment training, because of their varied experience and baseline knowledge they will not all leave the training completely proficient. To gain proficiency, the skills provided will require continued refinement once they arrive at or return to their unit. Postdeployment feedback from providers returning from deployment have lauded the training that TCMC provided, and commented about how much better prepared they felt to treat combat casualties in austere environment.

THE FUTURE

The Global War on Terrorism, the umbrella under which military operations following the attacks of September 11, 2001, were conducted, including Operation Iraqi Freedom and Operation Enduring Freedom as well as several other regional actions, had the lowest case fatality rate of all wars in which the United States was involved.¹⁻³ The TCMC course contributed to that statistic as the first conventional forces course to train TC3. Provider reports from the field demonstrate the importance of their new skills in combat casualty care, including the use of the walking blood bank during the battle of Combat Outpost Keating (Afghanistan, October 3, 2009).

The war on terrorism demonstrated early on that many providers are not familiar with Tactical Combat Casualty

Care, austere medicine, and military medical equipment sets. Future loss of the hard-fought gains in institutional knowledge learned from this conflict would be devastating, considering that approximately 90% of combat-related deaths occur prior to the casualty reaching a medical treatment facility.^{4,5} As such, the TCMC course should transition from a predeployment medical course to a provider sustainment course. It is necessary for it to become not only a requirement for all providers assigned to Role 1 and Role 2 locations prior to arriving at their unit and then every 2 years thereafter, but a priority. Part of this sustainment should include an evaluated training event 90 days prior to deployment to an austere environment to ensure proficiency in specific medical tasks.

The TCMC course also has an important role for physicians and physician assistants that are first entering the AMEDD as providers. True to the program's roots, the physician assistant and medical corps tracks in the Basic Officer Leadership Course are invaluable opportunities to provide this training so they report to their first assigned unit prepared. Accomplishing this will require funding and staff above the current levels.

Standardization of point of injury, Role 1 and Role 2 care across the brigade combat team and military is paramount; this can be done by providing TC3 training to all providers being assigned to a brigade combat team in the Brigade Healthcare Provider Course. Following this, physicians and physician assistants can attend a more in-depth hands-on track providing training and reinforcement as it relates to battalion aid station operations and skills.

Knowing that the military is moving from the current large pool of providers with deployment experience into a time of fewer numbers of them, extending and expanding this course is paramount. It will allow not only exposure to the field sets, skills and knowledge, but will allow for training and evaluation to move from exposure to proficiency and confidence. The extended course will also allow the addition of important content such as prolonged field care and tactical training.

The creation of a TCMC/TC3 web page will allow providers access to the most current TC3 guidelines and updates to help keep everyone up-to-date to provide consistent, evidence-based care. It will also serve as a platform for articles and learning activities that will provide CME credits related to tactical medicine. Course read ahead material coupled with a pretest on training day 1 would reduce some of the didactics and give way for more hands-on time and expansion into new topics.

Looking toward the expansion and refinement of tactical medicine, specific tracks will become necessary. Currently, the training is the same across the board for all attendees. The TCMC program can specialize course content to help providers at different stages across the continuum to further their knowledge.

CHALLENGES AND OPPORTUNITIES

Our military operates under constantly changing conditions in funding, resources, and battlefield environments. The TCMC program will continue to refine its instruction, continuing to provide the most realistic training and simulation coupled with the latest standards of care related to battlefield medicine. The transition of this course to a readiness and sustainment program ensures providers will continue to have the skills and knowledge necessary to deploy with a forward unit to a combat environment. A failure to adapt and transition the program now will result in closing of the doors at the end of the current conflict, ready for resurrection at the beginning of the next conflict, requiring resources, time, and the risk of unprepared providers. The program's transition will help ensure that the nation's most precious resource—its sons and daughters—return home.

REFERENCES

1. Holcomb JB, Stansbury LG, Champion HR, Wade C, Bellamy RF. Understanding combat casualty care statistics. *J Trauma*. 2006;60:397-401.
2. Holcomb JB, McMullin NR, Pearse L, et al. Causes of death in US Special Operations Forces in the global war on terrorism: 2001-2004. *Ann Surg*. 2007;245:986-991.
3. Kelly JF, Ritenour AE, McLaughlin DF, et al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 vs 2006. *J Trauma*. 2008;64(suppl):S21-S27.
4. Bellamy RF. The causes of death in conventional land warfare: implications for combat casualty care research. *Mil Med*. 1984;149:55-62.
5. Champion HR, Bellamy RF, Roberts CP, Lepaniemi A. A profile of combat injury. *J Trauma*. 2003;54(suppl):S13-S19.

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Lessons Learned: Employment and Tactical Use of The Combat Medic During Stability Support Operations

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ABSTRACT

It is the intent of this article to define the strategy by which Combat Medics have been employed in contemporary stability operations and counterinsurgency conflicts. This article describes the advances in training based on Tactical Combat Casualty Care and how training evolved into an evidence-based model. Training platforms evolved with shifts in mission requirements, new technology, improved medical techniques, and changing protocols. The last portion of this article details recommendations in doctrine, materiel, and training that could enable optimal sustainment standards while retaining operational capability across a wide variety of combat and peace operations. Lessons learned and changes adapted for Medics that are addressed: (1) advances in training and employment of the Combat Medic necessitated by tactics and strategy of current conflicts, (2) Combat Medic regulatory requirements and centralized, just-in-time training, and (3) changes in sustainment training driven by certification requirements and use of medical simulation training centers.

TRAINING AND EMPLOYMENT

From Baron Larrey to COL Letterman to the present day, the Combat Medic has continually evolved in many ways. From hospital stewards to litter bearers and Corpsmen, they have become ever more deeply ingrained into the very skin of the fighting element.¹ A Medic has been involved in every action from the start of WWI to every contemporary battle and hit and run action by the enemy, establishing a deeply developed level of trust from the Soldiers for whom they are responsible. It is the Combat Medic who first builds the bonds that enable the Flight Medic to deliver the Wounded to the surgeon. It is the Medic whom the Wounded Warriors remember most, or first, or last. It is the Medic that fights the sickle welding hooded beast and holds back the inevitable to send his comrade away; so the troops have hope—the platoon, the squad, the leaders do not yield to despair. The Combat Medic provides that foundation of confidence until the difficult job is done.

The last decade has seen a transformation of Combat Medics in both positive and a negative ways. Positive because of the advances in using evidence-based decisional processes which have resulted in an organized tactical care platform that is trusted throughout the world. Negative because training has been relegated to a centralized system of predeployment training using outside sources. This has eliminated the need for medical noncommissioned officers (NCOs) to be prepared to teach, coach, and mentor their Medics, Combat Lifesavers, and Soldiers in medical skills and evacuation processes. The system has provided multiple, externally provided training sources, meaning that NCOs are no

longer required to resource, prepare, or use the 8-step training model. In many ways, we have stopped developing Combat Medics who are capable of mounting a platform and instructing.

COMBAT MEDIC EMPLOYMENT IN STABILITY OPERATIONS AND COUNTERINSURGENCY

The last 14 years of armed conflicts have been challenging for Combat Medics, both tactically and technically. Their ability to operate in the new conflict paradigm has seen skill adaptations from Special Forces skill sets in the areas of affected population care management, use of organic medical assets by the mission commander to shape local government cooperation, and host nation asset evaluation for Civil Affairs and State Department missions. None of those functions are found in the Critical Task List of the Combat Medic.

Skill Level 10 tasks that 68W* Combat Medics have used in the current stability operations and counterinsurgency environment:

- ♦ Civilian primary care including assessment and treatment for common injuries and illness, identification and care for complex systemic problems, inoculations, and preventive care.
- ♦ Responding to farming and vehicular accidents in civilian sectors.
- ♦ Assessing civilian medical assets and recommending improvements to structures, manpower, training, and equipment.

*Military occupational specialty (MOS) 68W10 is the Army designator for Soldiers who are Combat Medics.

- ♦ Primary care for other US government and nongovernmental organizations.
- ♦ OB/GYN care provided by female Medics assigned to Special Operations Special Response Teams.

The most significant shift in the roles of Combat Medics has been the employment of individual Medics in austere, distant outposts. These forward operating posts are not readily accessed by ground evacuation assets and are therefore highly dependent on air evacuation. Given the generally good weather and unchallenged air superiority of our forces during the current conflicts, evacuation times to reach dispersed forward surgical or far forward resuscitative assets have been decreased to less than an hour. A prolonged weather event or the introduction of highly mobile, shoulder-fired anti-aircraft weapons would sharply effect our skill requirements. The ability to provide prolonged field care and hold critically injured patients for possibly extended periods due to this tactical shift is essential to the future needs of our Warfighters. This capability could include use of advanced resuscitative medication, invasive surgical and dental care, and critical care skills in antibiotics drugs and anesthesiology.

Another important change is that asset development of the medical plan has not been limited to preventing illness, injury, and treating trauma in combat forces. It has expanded to assist in mission accomplishment through leveraging the ability of the Combat Medic to gain the trust of civilians and local government officials.

Shaping expectations of what we do to assist in the mission often falls on very junior leaders. They rarely understand the complexities of what they are allowed to do and what is ethically acceptable for exploitation by the mission command. Beyond that, junior leaders usually have no concept of what effect they could have on the civilian services when they circumvent the civilian medical system.² As explained in *Joint Publication 3-07*:

The efficiency and effectiveness with which US forces can deliver humanitarian assistance, particularly medical and dental care, can have the unintended consequence of decreasing the population's confidence in the HN's [host nation's] ability to provide basic care. Possibly even worse, excessive US humanitarian assistance may delay and undermine the reconstitution of existing medical and other basic needs infrastructure in the HN.^{3(p111-22)}

This does not mean we should not prepare our Combat Medics for this mission, or even that it is unethical to shape civilian opinion through improving their medical care. The United States has had a high level of success in changing the level of medical care wherever our forces have been stationed. From epidemiological disease

control to extending the average lifespan by providing preventive care, clean water, and improved agriculture, the United States has exported healthcare improvements to every country in which it had occupation forces, or maintains current bases of convenience or treaty obligation.⁴ This was recently evidenced in the adaptation of a new emergency medical system in Iraq while the war in that theater was at its peak.² As Gresser points out:

Before military leaders probe a situation to discover solutions, they must determine what is morally required.^{5(p75)}

An excellent example of this kind of mission solution is the strategic use of medical personnel by then MG Petraeus in Mosul, Iraq, from 2003 to 2004 when he recognized that moral obligation based on the Geneva Convention to establish the "security and well-being of the Iraqi people in his area of responsibility."⁶

In future conflicts, we can expect not only the tactics and strategy to change, but also dramatic shifts in demographics coupled with emerging technologies to cause fundamental changes in the types of skills the military medical system will need to cultivate. Allenby characterizes this shift in perspective as:

...rather than rely on the aggression, emotion, and physical stamina of youth to rely more on the judgment, wisdom, and patience of older age.⁷

This shift could involve recruiting older enlistees, causing an even more dramatic shift in medical support of the force. The results would also guarantee more lessons learned from and changes made to our medical system.

CHANGES IN SUSTAINMENT TRAINING

Early in the last decade, the Combat Medic qualifications converted to a Department of Transportation (DOT) emergency medical technician (EMT) based certification, EMT-Basic (EMT-B). This was due in part as a solution to the issue of sustainment training and to align with the other services that had moved towards the DOT EMT program for ease of tracking training and perceived readiness. As the Army entered the current War on Terror conflicts throughout the world, it became obvious that EMT-B was *never* an adequate measure of Combat Medic readiness.

The issue is the certification level chosen for the Combat Medic. The EMT-B is the lowest level of certification for emergency medical service (EMS) personnel. They are normally limited to driving or preparing the ambulance for calls and are never assigned solo. They are always coupled with intermediate or paramedic level certified EMS members who have the experience and training to deal with complex urgent situations. This was part

of the plan in the initial stages of the Army's program. When the DOT EMT standard was adopted, the plan was for progression of medical certification skills as NCOs were promoted.⁸ In this way, an EMT-B would be partnered with an EMT-I or P. Testing of Soldiers in Initial Enlisted Training (IET) indicated that the pass rate of personnel straight out of school would be disastrous. Even though the plan was for the experienced NCO to assume those roles, a hold was placed on the ladder process, and then the war started. The immediate requirements for Medics in combat operations has seen the complete demise of the ladder process, and NCOs have almost no advanced medical skills training other than administrative.

In 1996, working within the Special Operations medical community, USN CAPT Frank Butler helped develop the Tactical Combat Casualty Care (TC3) initiative. The Special Operations Command implemented TC3 throughout its force, and it has quickly become the basis of all Combat Medic training over and above EMT-B. In IET, a Combat Medic (MOS 68W10) must pass the national registry EMT-B and then attend an additional 8 weeks of TC3 training. This provides a very substantial level of combat medical skills through the evidence-based process of the Committee on Tactical Combat Casualty Care (CoTCCC) oversight.

Most NCOs have not been trained in higher level medical skills and many have lost the skills needed to keep their Soldiers medically qualified. As a result, it has become necessary to create a centralized training program that ensures 90% of all medical personnel are "trained" prior to assignment in a current theater of operation. The Army Medical Department Center and School sends a mobile training team to train Medics at their home station in the United States or brings them to Camp Bullis, Texas, for training if they are in the National Guard or stationed outside of the United States. This "just in time" training program is not providing an adequate level of TC3 for units as they then do not train further on these skills as previously stated.

Currently, this "just in time" training is causing many second and third order effects. Most significantly is that Medics are not training their combat lifesavers, and physician assistants (PAs) are not training their Medics. The effects are noticeable when Medics try to use their combat lifesavers in casualty collection points, or when PAs working on trauma tables have to rely on their Medics for assistance. Additionally, battalion surgeons are not familiar with TC3, and are reluctant to allow their Medics to carry approved medications and equipment that is in the TC3 Guidelines and is taught in TC3 courses.

MISSION COMMAND AND OWNERSHIP OF CASUALTY CARE AND THE EVACUATION SYSTEM

Control and focus of lethality in the area of operations requires one centralized mechanism of control, one place through which all orders, reports, and requests must go. This includes casualty care and evacuation. Commanders must thoroughly plan, train, and rehearse, and completely own the process. No commander should take a unit into an active combat zone without full comprehension of casualty care and evacuation effectiveness. If commanders do not understand this system, they fail to uphold the standards of mission command. By failing to train, prepare, and understand this system, they are not prepared to take command of it in the battle space, causing them to lose overall visibility of the full combat operating situation.

During the last decade of operations, the 75th Ranger Regiment has effectively demonstrated combat casualty care and evacuation success. It has proven that TC3 must be rehearsed and supervised as part of the entire combat plan. Their efforts have resulted in less than 3% died of wounds rate during their operations.⁹ This is a direct result of the command taking ownership of the casualty care system and ensuring that everyone knows the process. The Commanding General, Joint Special Operations Command, then LTG Stanley McChrystal, implemented directives that made medical training and planning part of every Ranger's operational knowledge. He directed that every training event would incorporate TC3 and all live fires would build a TC3 event into the mission. It was a surprise to the Special Operations personnel, requiring them to deal with the mission and the casualty simultaneously. As a result, the 75th Ranger Regiment trains their combat lifesavers to EMT-B level, and their Combat Medics who are trained above a paramedic level are ingrained in every aspect of combat operations. No operations order is complete without a fully developed and supported casualty evacuation plan, and each aspect of medical operations is rehearsed throughout the planning phase.

CONCLUSIONS AND RECOMMENDATIONS:

A clinical ladder should be established which returns NCOs to technical applications and improves their prehospital medical capabilities.^{1,3,8,10} Throughout the Army, NCOs are regarded as technical experts in their respective specialty field. Yet Combat Medic NCOs stop receiving advanced training after the Advanced Leadership Course (ALC) when promoted from sergeant to staff sergeant. No training for emergency management is provided other than that received in Basic EMT in IET, and mass casualty operations in ALC. Senior NCOs are assigned to leadership roles that consume their time and

do not place them in contact with patients frequently enough to maintain primary care skills.

Collaborative development of curriculum must be enhanced and broadened with evidence-based guidelines provided through the Joint Training System and CoTCCC. A fully developed centralized system should be developed and marketed as the single true source from which all Combat Medics obtain their skill improvement, education, doctrine, sustainment, and qualification certificates. This should be in conjunction with establishment of a direct chain of leadership for pre-hospital medicine. Combat Medics need a support line that provides a consultant, a subject matter expert, and a system for building their healthcare knowledge and direction.

Even though it is the only evidence-based battlefield trauma system, TC3 is still not accepted by every commander, by every brigade surgeon, or members of the decision-making team in the tactical element. As a result, commanders do not train their medical teams as integrated assets in the operation; medics are not trained and issued analgesics other than morphine and evacuation assets are not devoted to support rapid transport to the closest higher level of care.

The 75th Ranger Regiment has had amazing success in decreasing preventable deaths with outcomes better than 3%. This is directly attributable to the mission commander making medical care a priority and owning it as a system of battle. The entire team, Ranger riflemen, gunners, drivers, cooks, and officers are all trained in TC3. Every time they train, they consider safety, and they rehearse TCCC. It has become an exercise as inherent as breathing.

REFERENCES

1. Ortiz JM. The revolutionary flying ambulance of Napoleon's surgeon. *US Army Med Dep J*. October-December 1998:17-25.

2. Donaldson RI, Hasson T, Aziz S, Ansari W, Evans G. The development of civilian emergency medical care during an insurgency: current status and future outlook in Iraq. *Ann Emer Med*. 2010;56:172-177.
3. *Joint Publication 3-07: Stability Operations*. Washington, DC: Joint Staff, US Dept of Defense; September 29, 2011. Available at: http://www.dtic.mil/doctrine/new_pubs/jp3_07.pdf. Accessed April 5, 2016.
4. Hudson W. *Army Diplomacy: American Military Occupation and Foreign Policy after World War II*. Lexington, KY: University Press of Kentucky; April 16, 2015.
5. Gresser RC. Macro-ethics and tactical decision making. *Mil Rev*. September-October 2014:72-80. Available at: http://usacac.army.mil/CAC2/MilitaryReview/Archives/English/MilitaryReview_20141031_art013.pdf. Accessed April 5, 2016.
6. Lundberg K. *The Accidental Statesman: General Petraeus and the City of Mosul, Iraq*. Cambridge, MA: Harvard University; 2006. Kennedy School of Government Case Program, C15-06-1834.0. Cited by: Gresser RC. Macro-ethics and tactical decision making. *Mil Rev*. September-October 2014:72-80.
7. Allenby BR. Senior soldiers: the thin gray line. *Bull At Sci*. 2014;70(5):86-95. Available at: <http://thebulletin.org/2014/september/senior-soldiers-thin-gray-line7594>. Accessed April 5, 2016.
8. De Lorenzo RA. Improving combat casualty care: focus on the military medic. *US Army Med Dep J*. January-February 1998:24-30.
9. Kotwal RS, Montgomery HR, Kotwal BM, et al. Eliminating preventable death on the battlefield. *Arch Surg*. 2011;146(12):1350-1358.
10. Mabry RL, De Lorenzo RA. Improving role I battlefield casualty care from point of injury to surgery. *US Army Med Dep J*. April-June 2011:87-91.

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CONCLUSION

Army Medical Department at War: Healthcare in a Complex World

COL Clinton K. Murray, MC, USA
MG Stephen L. Jones, MC, USA

As of February 28, 2014, 1,308,626 US Soldiers had deployed in support of Operations Enduring and Iraqi Freedom. Of them, 808,969 were Active, 336,043 were National Guard, and 163,614 were Army Reserve. Many of them, 383,492 Active, 107,906 Guard and 52,097 Reserve component Soldiers, deployed more than once. Department of Defense casualties from October 2001 through March 2014 include 5,332 killed in action, 1,453 nonhostile deaths, and 51,932 wounded in action (Figure 1).¹ The Army has sustained 3,877 killed in action, 1,044 nonhostile deaths, and 36,421 wounded in action (WIA) (Figure 2).¹ Approximately 33% of Army WIA required evacuation out of theater. Of the Soldiers wounded, 44% remained on active duty or inactive reserve and 17% WIA were medically separated. During a conflict that saw dramatic increases in the severity of injuries, equally dramatic improvements in casualty care from the point of injury through rehabilitation greatly improved survival (Figure 3). Our nation owes a tremendous debt to the service members who sacrificed so much during the current conflict, including the medical personnel who stood shoulder to shoulder with them on the battlefield and the families who supported them back home. While we continue to care for those who currently serve in Iraq and Afghanistan, we must also begin preparations to care for the casualties of future conflicts.

The *US Army Operating Concept, Win in a Complex World*² describes the future environment as unknown, unknowable, and constantly changing. The technological advantage the US military has enjoyed over its adversaries since 1945 is diminishing. War remains a fundamentally human endeavor and the Army is preparing Soldiers to succeed by maintaining its edge in the human dimension of combat power. The US Army Human Dimension Strategy focuses on the cognitive, physical, and social components of professionals and teams.³ Its lines of effort—agile, adaptive leaders; realistic training; and institutional agility—are incorporated into Army Medicine's ready medical force model (Figures

4 and 5). Army Medicine is applying the human dimension strategy to prepare Army Medical Department (AMEDD) personnel for the increasing complexity and uncertainty ahead. Army Medicine must be prepared for the full spectrum of military operations from major combat through humanitarian missions. It will play a major role in shaping the security environment and developing the capabilities of partners and allies. Combat medics in the future may control truncal hemorrhage while under fire, and laboratory technicians may provide rapid confirmation testing for Ebola in West Africa.

Like armed conflict, healthcare is a complex, risk-filled human endeavor. Military healthcare is even riskier, more emotionally charged, and filled with uncertainty. Army Medicine requires leaders who can thrive and grow in this environment. These leaders build the teams who provide care on the battlefield, in the operating rooms, intensive care units, wards, and clinics. They provide the purpose, direction, and motivation necessary for safe and effective care. The Squad Overmatch Study applies the human dimension concept while training the infantry squad as a team. It builds on existing warrior skills training and incorporates team building, situational awareness, resilience and performance enhancement, and tactical combat casualty care. It also provides a framework for squads to conduct after action reviews and take ownership for improving their team performance (Figures 6 and 7). This model applies equally well to building the AMEDD teams who care for warfighters and their families.

We do not know when or where we will fight in the future. We may be called upon to deploy in days, or a few hours. Our adversaries will continually adapt and present us with new and more difficult challenges. We may operate in remote locations, under austere conditions, with long lines of communication. We may find ourselves in ungoverned megacities or face technologically advanced near-peer competitors. Communications may

CONCLUSION

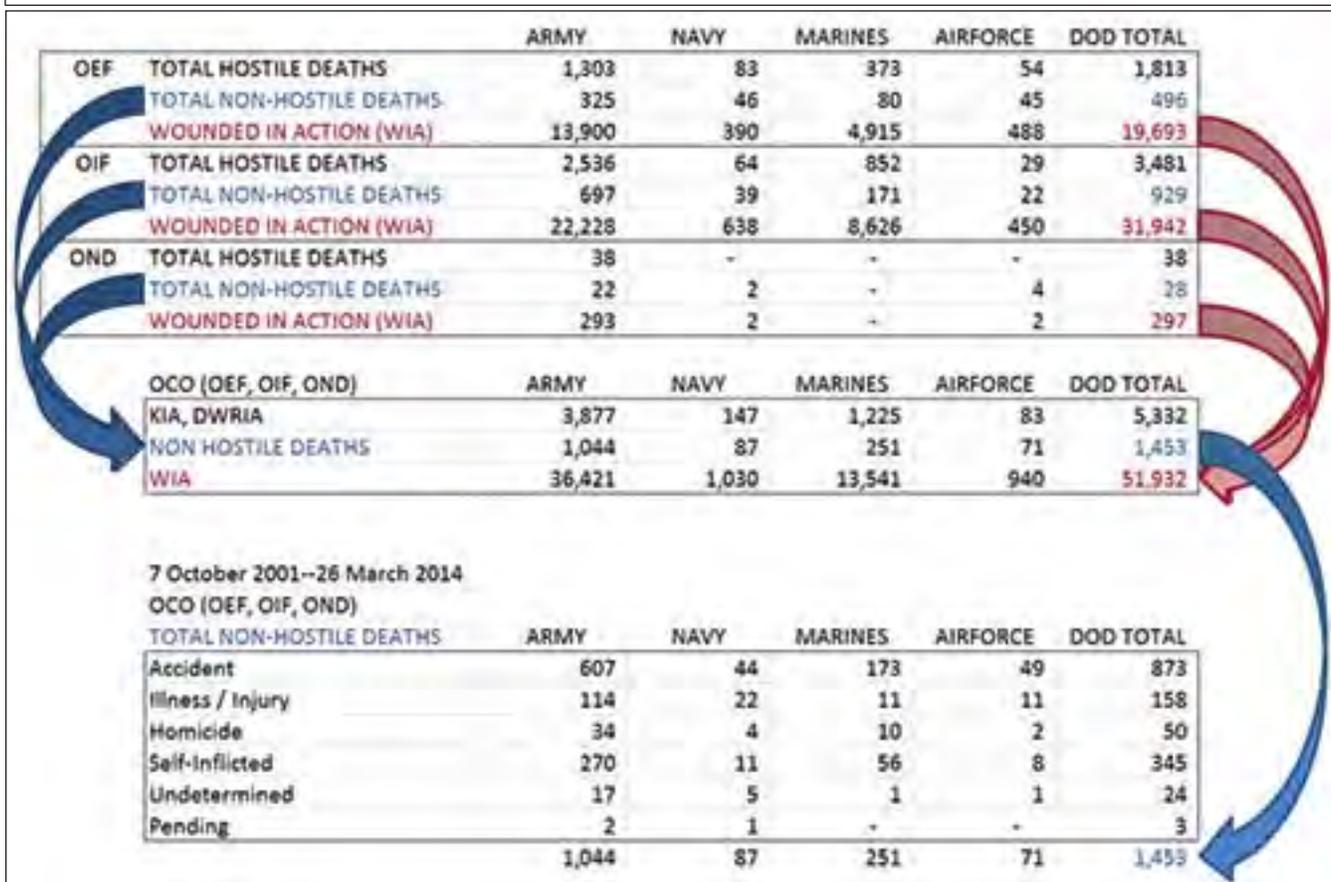


Figure 1. Reported deaths and wounded in action by military service, and mechanism of nonhostile deaths (source: Carino¹).

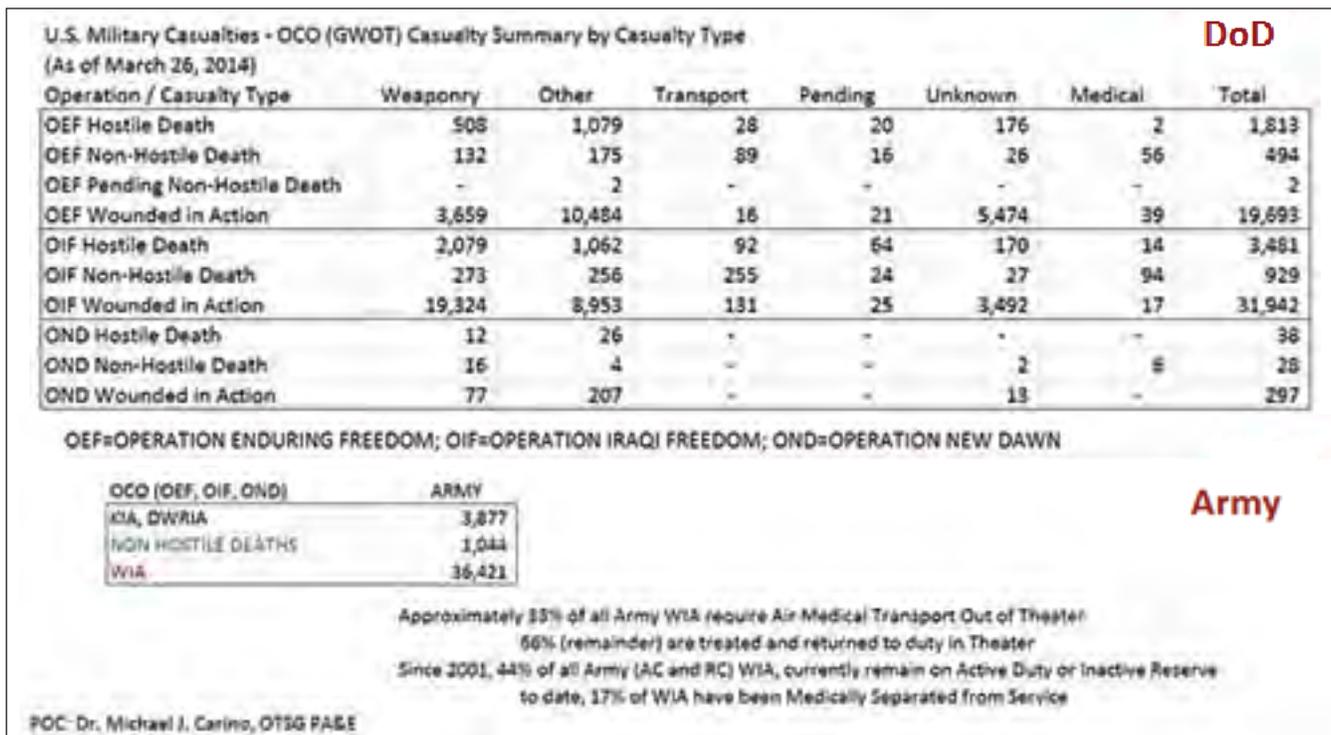


Figure 2. Casualty types for Department of Defense overall and US Army specifically.

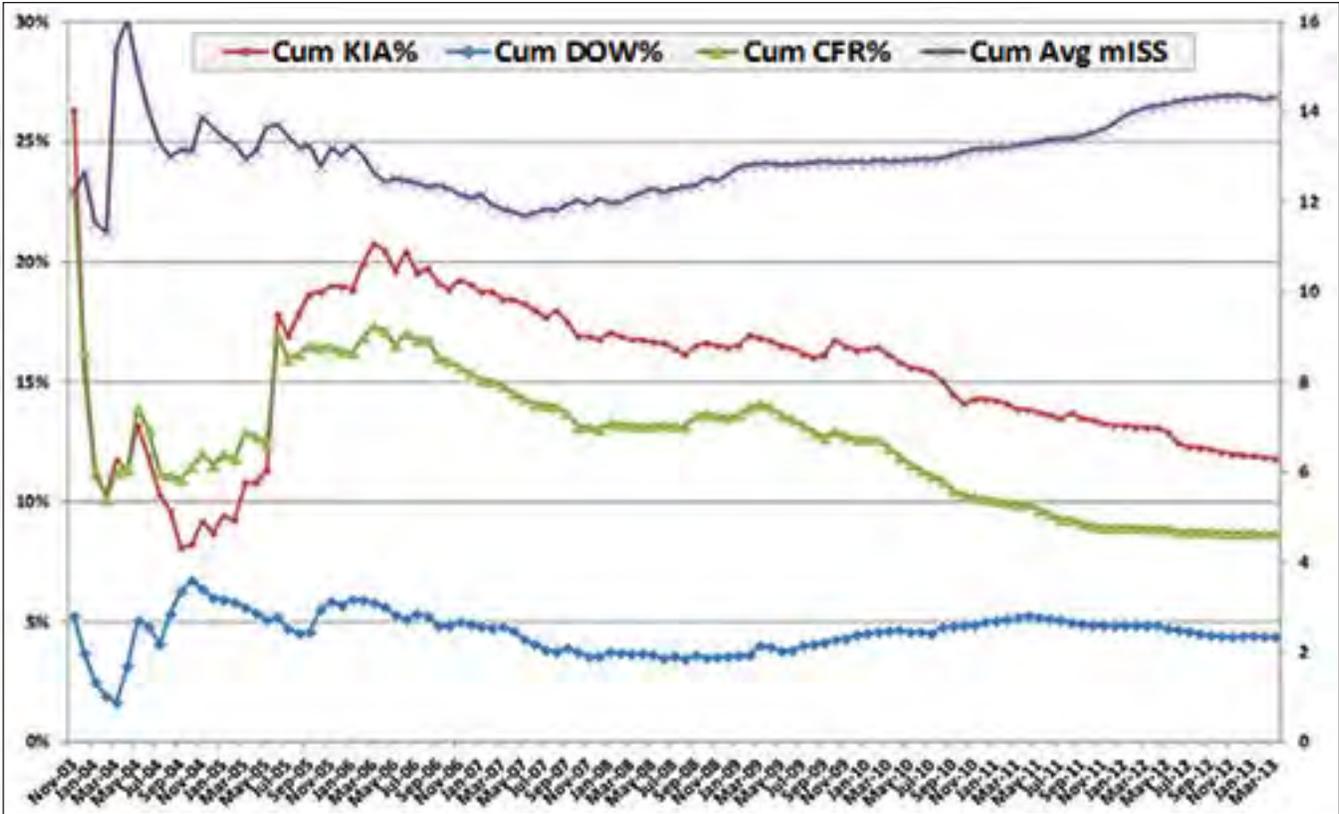


Figure 3. Cumulative rolling monthly averages of killed in action, died of wounds, and case fatality rate during operations in Afghanistan, November 2003-March 2013.

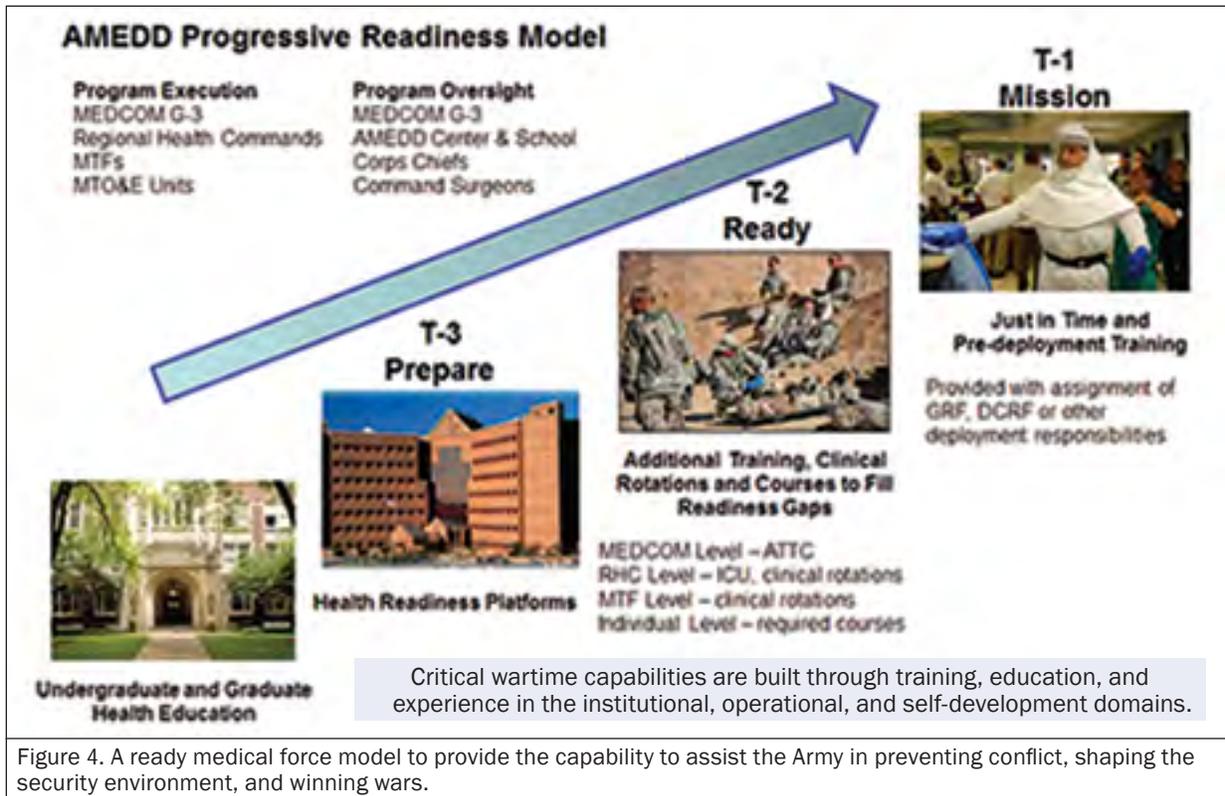
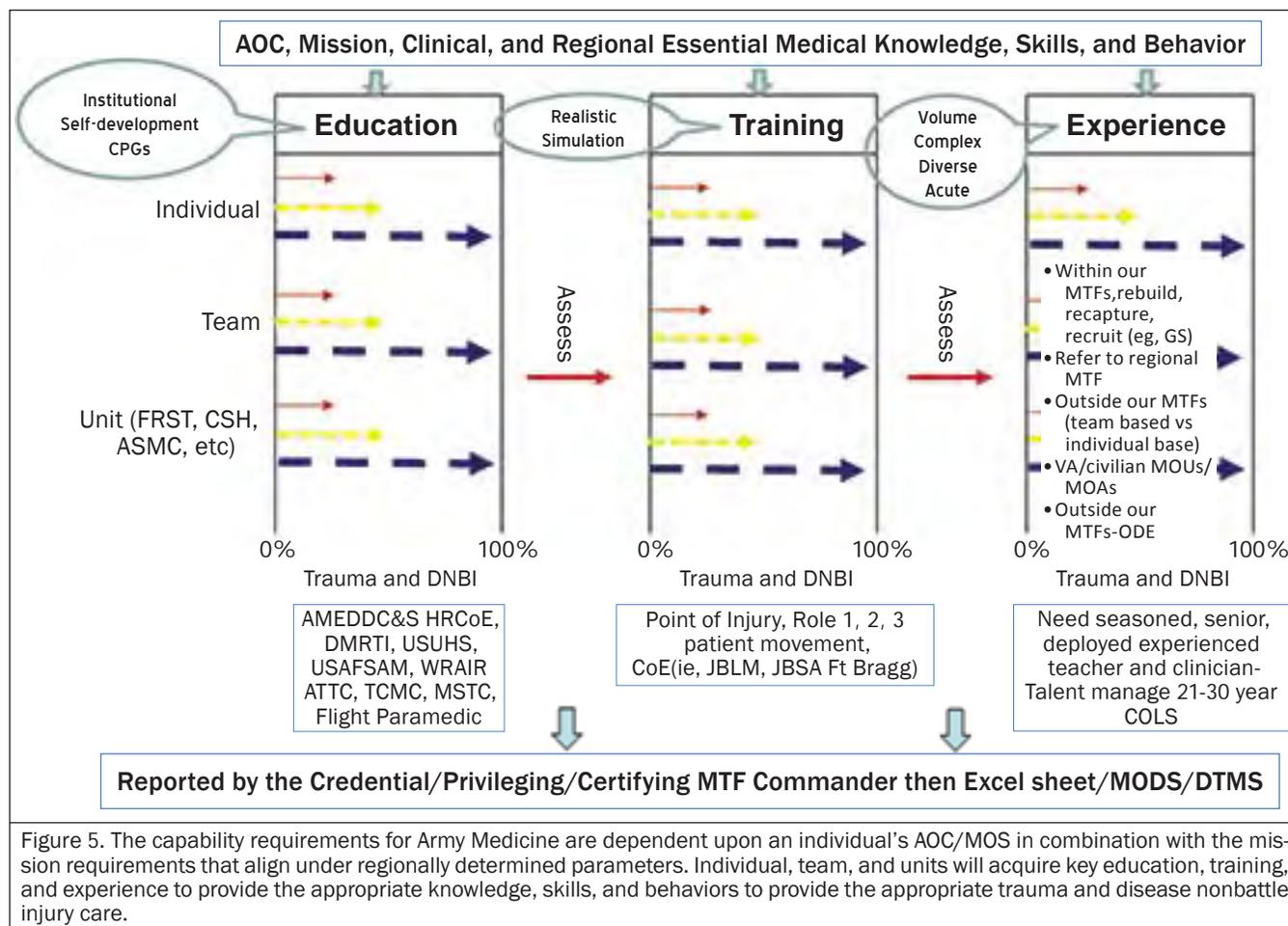


Figure 4. A ready medical force model to provide the capability to assist the Army in preventing conflict, shaping the security environment, and winning wars.

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be degraded, casualty evacuation delayed, and medical personnel may provide prolonged field care. We face many of these challenges around the world today. In Africa, evacuation distances are measured in thousands of miles. In Afghanistan, the Golden-Hour Offset Surgical Treatment-Mission provides casualties with lifesaving damage control resuscitation/surgery near the point of injury. The concept of prolonged field care may begin on the front lines, but it has implications for every subsequent level of evacuation and treatment. It applies not only to trauma but also to disease and nonbattle injuries. Prolonged care of a patient with a pulmonary embolism or cerebral malaria in the field will require skills not traditionally taught in our schools or military treatment facilities. New approaches to education and training, new organizational structures, equipment, and greater reach back capability will be required for successful management of complex patients who are awaiting evacuation.

Within the lectures and papers presented in this edition of the AMEDD Journal are key lessons learned for each of the components of the DOTMLPF-P* domain. The discussion at the end of the symposium raised further issues

to consider as we look to the future of Army Medicine. The questions presented below range from the tactical to the strategic level and apply across all AMEDD Corps:

1. How do we effectively capture the lessons of a conflict, apply them in real time to provide advances in care, and document them for those who follow us?
2. How do we identify and apply the enduring lessons of the current conflict while preparing for the new challenges of the next?
3. What is the best format to distribute lessons learned more broadly, rapidly, and effectively? What is the appropriate use of handbooks, clinical practice guidelines, doctrine, and policy changes?
4. How do we ensure the National Guard and Reserves are incorporated into readiness and lessons learned programs?
5. How do we best transition from a counterinsurgency campaign and prepare for the full range of military operations where ground and air evacuation may be more difficult, communications degraded, and

SOvM-TC3
A Balance of Converging of Challenges

Building Squad Capability is the Key to the Decisive Force

Win in a Complex World F2025B
The U.S. Army Operating Concept
Win in a Complex World

Fiscal Constraints
BUDGET

Tactical Combat Casualty Care
Tactical Combat Casualty Care
PROXIMAL TRAUMA LIFE SUPPORT

Improved Learning Model to Provide Relevant Training ALC 2015
The U.S. Army Learning Concept for 2015

Sustaining Readiness
ARE YOU READY?
ARAP
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The Human Dimension
SQUAD OVERMATCH STUDY
HUMAN DIMENSION

Optimize Human Performance
Optimize Human Performance

Developing Ready and Resilient Warriors
READY AND RESILIENT

THE ARMY HUMAN DIMENSION STRATEGY

Figure 6. Overview of the Squad Overmatch Study assessing Tactical Combat Casualty Care and the areas that influence the squad's capability.

SOvM-TC3 is Balanced Across Multiple Life Saving Domains

Squad Overmatch Study-TC3 and is an expansion of the SOvM 2014 study with improvements in curriculum design and new technology integration leveraging existing Program of Instruction (POI) & Program of Record (POR) demonstrating the Integrated Training Approach.

Advanced Situational Awareness (ASA)
Enables pattern/threat recognition and decision making in complex environments.

Team Dimensional Training (TDT)
TDT develops teamwork skills: Information Exchange, Communication Delivery, Supporting Behavior, & Initiative/Leadership.

Integrated After Action Review (IAAR)
AAR framework designed to facilitate squad initiative and ownership in AAR execution.

Tactical Combat Casualty Care (TC3)
Training effective communications and decision making in managing combat casualties.

Resilience and Performance Enhancement (RPE)
Training to help the squad maintain tactical effectiveness under combat stressors.

Building on Existing Warrior Skills Training

Figure 7. The 5 primary life-saving domains required for successful squad performance.

CONCLUSION

The Strategic Landscape that Influences the Future of Army Medicine Including Concept of Operations and Readiness.

Joint Medical Concept Required Capabilities	Army Warfighting Challenges	ATP 4-02-55 Army Health System Support Planning Medical Functions	Medical Warfighting Functions
Joint medical planning	Develop situational understanding.	Medical mission command	Medical mission command
Joint theater directed coordination, synchronization, and medical situational awareness	Shape the security environment.	Medical treatment	Prehospital care
Monitor patient outcomes, assess clinical effects, and adapt operations.	Provide security force assistance.	Medical evacuation	Primary care
Joint force development framework for health services	Adapt the institutional Army.	Hospitalization	Evacuation and enroute care
Medical mitigation of the environment	Counter weapons of mass destruction.	Dental services	Hospital care
Joint credentialing and privileging	Conduct homeland operations.	Preventive medicine services	Rehabilitation and definitive care
Medical treatment facilities	Conduct space and cyber electromagnetic operations and maintain communication.	Combat and operational stress control	Force health protection
Patient evacuation	Enhance training.	Veterinary services	Medical sustainment
Patient management	Improve soldier, leader and team performance.	Medical logistics	Medical engagement
Joint medical leader development	Develop agile and adaptive leaders.	Medical laboratory services	Medical information
Medical intelligence	Conduct airground reconnaissance.		Research and innovation
Joint and service medical education and training	Conduct entry operations.		
Joint medical research and development	Conduct wide area security.		
Medical logistics	Ensure interoperability and operate in a joint, interorganizational, and multinational environment.		
Health services contracts and resource programming	Conduct combined arms maneuver		
Global health services network	Set the theater, sustain operations and maintain freedom of movement.		
	Integrate fires.		
	Deliver fires.		
	Exercise mission command.		
	Develop capable formations.		

operations may be conducted in megacities or a CBRN* environment?

6. How do we develop the critical thinking skills required for healthcare in a complex world?
7. How do we retain the expertise gained across all AOC/MOS and Roles of Care in the current conflict?
8. How do we provide the education, training, and experience necessary for casualty care within our schools, MTFs, and in the civilian community?
9. How can we best use our senior NCOs to provide education, training, and experience in garrison?
10. How do we best develop and implement the concept of multidisciplinary teams providing casualty care from the front lines through rehabilitation, without an artificial distinction between care in theater and care at home?
11. How do we transition from an AMEDD focused on AOCs/MOSs* to one focused on required capabilities? How do we capture the transition in our monitoring and reporting systems?
12. How do we ensure modularity and scalability across the full spectrum of operations?
13. Given the lack of SIPR* access for most in Army Medicine, especially in the Army Reserve and Guard, how do we improve communication within NIPR* and/or SIPR channels?
14. Does the current PROFIS* model adequately address requirements of the sustainable readiness model?



Figure 8. The full support that Army Medicine provides the Warfighter from point of injury to rehabilitative care.

15. How can the Army Medical Command collaborate more closely with operational and special operational forces?
16. How do we modify our business processing and monitoring systems to measure the education, training, and experience components of readiness?
17. How do we use Role 1, 2, and 3 outcome data to validate the effectiveness of predeployment training programs including Tactical Combat Management Course, Army Trauma Training Course, and Joint Forces Trauma Management Course?
18. How should we select, train, and evaluate personnel for operational assignments? How do we best develop their knowledge, skills, and behaviors prior to their assignment?
19. How should we optimize the electronic health record to facilitate treatment and support quality improvement programs?
20. How do we use CCQAS,* credentialing, and privileging to document and manage training, education, and experience readiness requirements across both the Army Medical Command and operational units?

CONCLUSIONS

As we emerge from the mountains and deserts of Afghanistan and Iraq, we must prepare for a future that is unknown, unknowable, and constantly changing. We can study the lessons of the hybrid war being conducted in eastern Ukraine, the conflicts in Syria and Africa, and terrorism in Europe. At the same time, we must maintain situational understanding of the entire world since any region be our next battlefield. Army Medicine will face these challenges and, as in the past, it will adapt and overcome them. It will face them as a team that includes all Components and Army Civilians. It will draw guidance from the Army Operating Concept and Joint Concept for Health Support. As shown in the Table, the

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Army Warfighting Challenges, Joint Essential Medical Capabilities and Medical Warfighting Functions will serve as the framework for analysis of new concepts.⁴⁻⁶ It will address the entire continuum of casualty care from the point of injury through evacuation, definitive care, rehabilitation, and reintegration (Figure 8).

REFERENCES

1. Carino MJ. Army Casualty: Summary Statistics Overview–Update [presentation]. Falls Church, VA: Office of the Army Surgeon General; March 27, 2014.
2. *The U.S. Army Operating Concept, Win in a Complex World 2020-2040: TRADOC Pamphlet 525-3-1*. Fort Monroe, VA: US Army Training and Doctrine Command; October 31, 2014. Available at: <http://www.tradoc.army.mil/tpubs/pams/TP525-3-1.pdf>. Accessed December 15, 2015.
3. *The Army Human Dimension Strategy 2015*. Washington, DC: US Department of the Army; 2015. Available at: http://usacac.army.mil/sites/default/files/publications/20150524_Human_Dimension_Strategy_vr_Signature_WM_1.pdf. Accessed December 15, 2015.
4. *Joint Concept for Health Services*. Washington, DC: Joint Staff, US Dept of Defense; August 31, 2015:2. Available at: http://dtic.mil/doctrine/concepts/joint_concepts/joint_concept_health_services.pdf. Accessed December 15, 2015.
5. *Force 2025 and Beyond. Unified Land Operations. Win in a Complex World*. Fort Monroe, VA: US Army Training and Doctrine Command; October 2014. Available at: http://www.arcic.army.mil/app_Documents/tradoc_ausa_force2025andbeyond-unifiedlandoperations-wininacomplexworld_07oct2014.pdf. Accessed December 15, 2015.
6. *Army Techniques Publication 4-02.55: Army Health System Support Planning*. Washington, DC: US Department of the Army; September 2015. Available at: http://armypubs.army.mil/doctrine/DR_pubs/dr_a/pdf/atp4_02x55.pdf. Accessed December 15, 2015.

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*DOTMLPF_P indicates Doctrine, Organization, Training, Material, Leadership, Personnel, and Facilities.

CBRN indicates chemical, biological, radiological, nuclear.

AOC/MOS indicates area of concentration/military occupational specialty.

SIPR indicates secure internet protocol router.

NIPR indicates nonsecure internet protocol router.

PROFIS indicates the Professional Filler System which predesignates qualified Active Army AMEDD personnel to fill positions in early deploying and forward deployed Army medical units upon mobilization for execution of an operations plan or a contingency operation, or for the conduct of mission-essential training.

CCQAS indicates Centralized Credentials Quality Assurance System, an internet-based, worldwide credentialing, privileging, risk management, and adverse actions database for the Defense Health Agency.





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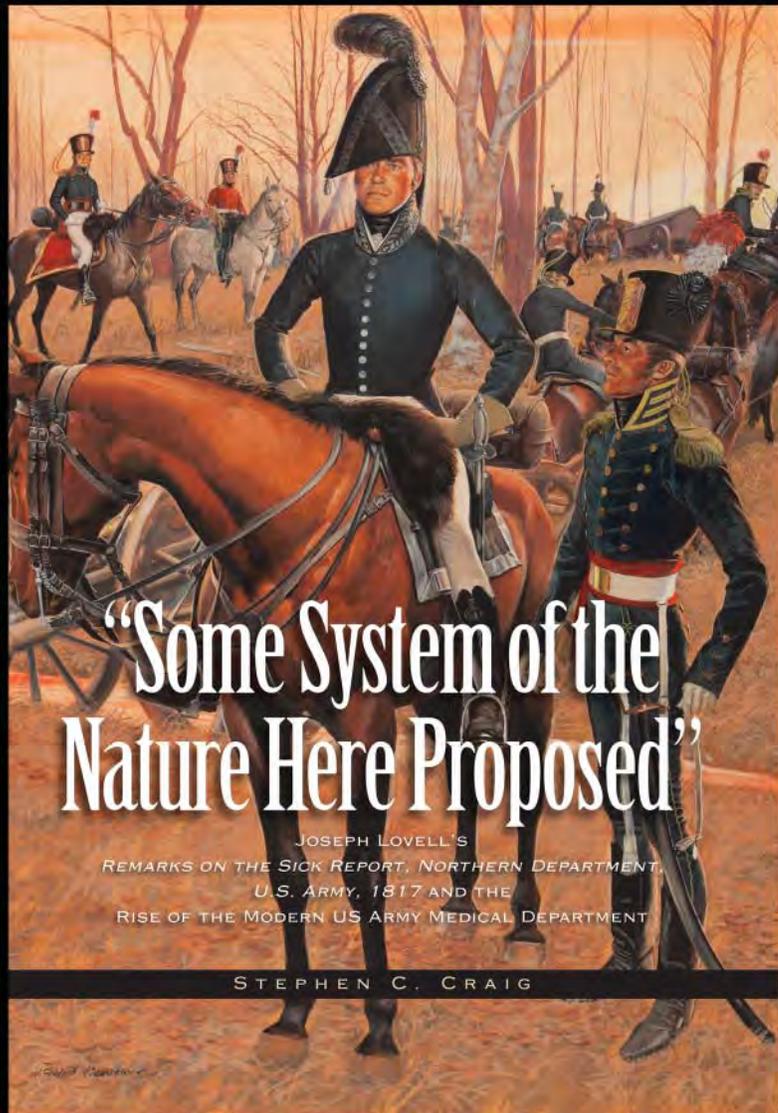
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