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Traumatic Wound Care
On and Off the Battlefield

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Perspective

Major General Russell J. Czerw

The focus of this issue of the *AMEDD Journal* is an area of medicine that is in fact the very basis for the existence of military medicine, management of trauma injuries incurred in combat. Indeed, the medical care of US military personnel injured on the battlefield has never been better, in terms of both survival and recovery. However, as rapidly as our medical capabilities improve in sophistication and effectiveness, so too do the capabilities of our enemies increase in sophistication and lethality. We must, therefore, always be seeking better ways to address the injuries suffered by our Soldiers as they go into harm's way. This issue of the *AMEDD Journal* does exactly that with a presentation of real world experiences of our medical professionals from the battlefields of today, and relevant, practical recommendations as to how we can do a better job for our Soldiers on battlefields of the future.

LTC Lorne Blackbourne and his coauthors open with a series of 3 well-researched, detailed articles addressing various ways to improve survivability of trauma casualties from their earliest damage control surgeries. In the first article, the emphasis is not on the surgery itself, but on 2 other potentially lethal conditions attendant to the trauma, coagulopathy and hypothermia. The article packs a tremendous amount of extremely important information into a few pages, and includes logical, practical recommendations for both current operations and future planners. Next is a directly related article, expanding on the availability and use of blood products in damage control surgery to address the coagulopathy and related acidosis and hypothermia of trauma. This is another clear, concise presentation in which they propose the creation of blood augmentation teams to provide blood transfusion, processing, and storage capabilities on the battlefield, especially at the level of the Forward Surgical Team. LTC Blackbourne and his team wrap up the discussions of survivability of battlefield trauma with an expanded examination of the challenges inherent in the evacuation of injured Soldiers to combat support hospitals. The article is a thorough analysis of all of the potentially deadly hazards associated with the helicopter transport of those who have undergone damage control surgery. Again, a concise, thoroughly referenced, and complete discussion of an aspect of trauma care which is often underappreciated as to its complexity and importance in the ultimate survivability of our Soldiers.

LTC Shaun Machen relates his experience in the development of a protocol for the use of vacuum-assisted closures in the treatment of traumatic wounds at the combat support hospital. His detailed discussion of the hugely successful adaptation of this technology into the austere environment of combat medicine is another example of the skills, resourcefulness, and, above all, dedication of the medical professionals in today's Army. The results of LTC Machen's efforts speak for themselves. The information in his article should be of great interest to all of you who work with traumatic wound injuries, especially in the combat environment.

COL John Holcomb and his team of specialists undertook the vitally important task of analyzing the causes of death for US military personnel in the current theaters of combat operations. Their article is a meticulous study, not only of the injuries and

treatments, but also the environments, situations, and sequence of events surrounding the injuries which were ultimately fatal. COL Holcomb et al present statistical data and case studies to support their detailed discussion of both the considerable successes and possible shortcomings in the care of these trauma victims. This is a sobering yet encouraging look at those situations when all of the best of our training and technology may not be enough. It is a must read for all of us.

The majority of the wounded who are evacuated to medical facilities in the United States arrive with extremity and other orthopaedic injuries which require treatment and rehabilitation as the Soldier recovers. COL William Doukas has assembled a collection of articles written by the professionals at Walter Reed Army Medical Center describing the structure and processes that have evolved as the influx of wounded increased concurrent with the tempo of combat operations. Each specialty in the chain of orthopaedic care—orthopaedic surgery, physical therapy, physical medicine and rehabilitation, and occupational therapy—have contributed, describing their respective responsibilities, procedures, adaptations, conclusions, and recommendations for improvements in the care of our most seriously injured Soldiers.

In the Global War on Terrorism, the role of the occupational therapist is becoming an increasingly prominent part of the recovery regimen for those who have suffered traumatic combat injuries. However, few people probably know that the need for what is now known as occupational therapy was first recognized in the 18th century. MAJ Sharon Newton's article is an interesting and informative description of the evolution of occupational therapy as a treatment discipline which has become integral to military medicine. Her well researched, chronological presentation illustrates how interest in use of the therapists has surged and waned in conjunction with medical, societal, and political trends. She shows how the discipline has endured a number of incarnations before it finally emerged as a recognized, sophisticated field, practiced by trained, skilled professionals who are key members of today's treatment team for our wounded Warriors.

MAJ Bonnie Hartstein contributes an article which presents another aspect of current medical support in the theater of combat operations. As Brigade Surgeon of the 15th Sustainment Brigade at Camp Taji, Iraq, she has experienced the challenges of managing medical support for Soldiers in one of the new modular Army organizations as it transforms from a peacetime, headquarters element to a large, integrated, multifunctional entity deployed into the theater of operations. In her article, MAJ Hartstein describes the complexities and tradeoffs involved in planning and providing for the healthcare of sustainment brigade Soldiers deployed into the dynamic, nonlinear battlefield environment of today. She spotlights an area of major concern which must be promptly addressed at the top levels of planning for medical support for our new, modular Army.

The final article in this issue is a very timely and relevant discussion of an evolutionary approach to providing both accessible and affordable quality medical care throughout the medical profession. COL Herman Barthel presents an in-depth look at the history and basis for the application of evidence-based medicine (EBM) in the delivery of health care. It seems only logical that in this era of virtually instant access to current information, medical care should be based on scientific evidence used to support the practitioner's judgment and specific case knowledge. However, such an approach is not universally applied. Indeed, much health care delivery is still based on tradition and uncontrolled clinical experience. COL Barthel presents a sobering description of the implications of the skyrocketing costs of health care, not only on the personal health of our citizens, but also the impact on our national security. He provides examples of the success of an institutionalized approach of the application of EBM to healthcare delivery, and presents recommendations for steps to help make EBM a standard for our national healthcare policy.

Aggressive Proactive Combat Damage Control Surgery

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CPT Neil McMullin, MC, USA
COL Brian Eastridge, MC, USA
COL Toney Baskin, MC, USA
COL John Holcomb, MC, USA

Proactive: [pro- + reactive]: acting in anticipation of future problems, needs, or changes[1]

INTRODUCTION

Damage control surgery is the process of preventing, in a proactive fashion, the overwhelming catastrophic physiologic effects of severe hemorrhage. While the damage control "trilogy" of (1) abbreviated surgical operation, (2) postoperative intensive care unit resuscitation, and (3) definitive operation is described as the major tenets of damage control, there are many extremely important contributing efforts that are critical to the success of the process.[2] In civilian practice, the order of this damage control trilogy is well established. However, the military paradigm of combat damage control often creates a variable continuum for the major tenets of this trilogy with a more variable time span.

While the current combat damage control surgery stresses early surgical operation, there are currently no universal proactive hypothermia or coagulopathy prevention strategies for forward surgical level II facilities. Aggressive damage control surgery is used to proactively defeat the "lethal triad." This triumvirate of hypothermia, acidosis, and coagulopathy all feed on each other in a feedback cycle, and once in full fruition is universally fatal. Our only tangible targets of this lethal triad are hypothermia and coagulopathy. A more inclusive proactive approach to combat damage control surgery would mandate that we develop measures to counter coagulopathy and hypothermia earlier on the resuscitative time line.

PROACTVE COAGULOPATHY PREVENTION AND TREATMENT

Coagulopathy is not merely a number or a laboratory value. Coagulopathy can be obvious clinically to the surgeon and anesthesia personnel. Coagulopathic bleeding can easily be seen as profuse bleeding from any raw anatomic surface and from multiple fragmentation wounds. Coagulopathic bleeding is also a marker and a risk factor for death in these damage control patients.[3] Replacing the patient's blood which contains clotting factors, fibrinogen, and platelets with only packed red blood cells (PRBCs) which do not contain any clotting factors, fibrinogen, or platelets can actually worsen the coagulopathy due to simple dilution.[4] A major difference between civilian damage control and far-forward combat damage control surgery is the use of blood products. The majority of civilian damage control patients who receive 10 units of PRBCs also receive fresh frozen plasma (clotting factors) and platelets.[5] In comparison, military combat damage control patients usually receive only PRBCs. Hirshberg et al state that to optimally treat and prevent coagulopathy in damage control patients, the clotting factors and platelets need to be transfused proactively before the onset of a documented coagulopathy.[6] Options for treating a coagulopathy include recombinant factor VIIa, fresh frozen plasma (FFP), platelets, and whole blood. Fresh whole blood (<8 hours old) contains clotting factors, fibrinogen, and platelets. Due to a limited donor pool, limited personnel, and variable expertise, drawing whole blood can be a very challenging activity to the full engaged level II surgical facility. Fresh frozen plasma must be kept in a frozen state (until thawed for transfusion) and in significant quantities due to a lack of a truly universal donor blood type (ie, must be a blood type specific transfusion). Lack of freezer capabilities at level II facilities currently make FFP a nonviable option. Platelets must be stored near room temperature and have a storage life, after processing,

of approximately 5 days, making their appearance in the combat zone unfeasible. Factor VIIa can be stored in a refrigerator with the PRBCs and has great potential in far-forward combat damage control.

If we are to maximize combat damage control, we need to find strategies that will effect the lethal triad early in a proactive, aggressive approach. "Playing catch up" at a level III surgical facility places those combat wounded in a serious predicament with mortality and morbidity.

PROACTIVE HYPOTHERMIA PREVENTION AND TREATMENT

The other area of the lethal triad that we can directly impact is hypothermia. Hypothermia is extremely detrimental to damage control, especially the combat wounded damage control patient, as the hypothermia makes the coagulopathy of the lethal triad worse. Hypothermia also inhibits platelet activation.[7] Thus, hypothermia inhibits the 2 procoagulant processes upon which current level II surgical facilities cannot make an impact in most cases.

In civilian damage control patients, hypothermia has been documented to be a risk factor for death.[8-12] Improved hypothermia prevention in civilian damage control patients is thought to be a factor in overall better outcome in damage control patients in recent years.[13] Furthermore, preventing hypothermia has been documented to decrease the overall blood and intravenous (IV) fluid requirements of damage control patients. Blood and IV fluid are a great concern to the highly mobile, logistically challenged level II surgical facilities.[14]

A proactive, aggressive approach to hypothermia prevention and treatment early during the course of combat damage control surgery will help decrease the overall blood transfusions, IV fluid usage, and overall mortality of combat wounded.

PROACTIVE CARE DURING ROTARY-WING TRANSPORT FROM LEVEL II TO LEVEL III

One area unique to combat damage control surgery is the rotary-wing evacuation of postoperative patients to a level III facility to undergo completion of the intensive care unit resuscitation phase of damage control. A great peril exists during this evacuation. Hypothermia can be profound if measures are not undertaken to ensure thermoregulation. Currently, most postoperative patients are transferred with wool blankets and possibly an outer shell consisting of a modified body bag. Convective warming systems (eg, Bair Hugger®, Arizant Healthcare Inc, 10393 West 70th Street, Eden Prairie, MN 55344) have been documented to optimize preservation of body warmth in intrahospital transfers.[15]

FUTURE SOLUTIONS

Blood Augmentation Units

The first step in maximizing the treatment of coagulopathy in combat damage control patients is to bring personnel with expertise into the level II surgical facilities. A single blood bank expert (or additional training of forward surgical team personnel at a medical center in the United States) could provide immediate expertise in drawing and cross matching fresh whole blood (including rapid HIV and hepatitis screening). This individual could also ensure the adequate storage of PRBCs and factor VIIa.

The second step (the optimal situation) would be the creation of a platform for refrigerators and freezers. This capability would allow for the storage of additional PRBCs and for the advent of blood products at level II facilities. These blood products could include FFP and cryoprecipitate.

Adding the capability to transfuse adequate PRBCs, factor VIIa, fresh whole blood, FFP, and cryoprecipitate would enable the level II surgical facilities to provide treatment of damage control coagulopathy at the level of a civilian level I trauma center.

Universal Hypothermia Prevention and Treatment Measures

The use of convective warming systems and IV fluid warmers can make the most immediate impact on thermoregulation in combat damage control patients at level II surgical facilities.

Convective warming systems (eg, Bair Hugger) have been demonstrated to help maximize body core temperature preservation in trauma patients and in patients undergoing an operation.[16-19] These systems can be utilized to warm patients in preoperative holding, in the operating room, and postoperatively.

Blood and IV fluid warmers provide the ability to maximize and warm infusion volumes. Fluid warmers have been documented to help maintain body temperature in surgical and trauma patients.[20] The use of a rapid infusion warming device has been documented to decrease the overall blood and fluid requirements in the severely wounded trauma patient, again a major benefit for our logistically challenged far-forward surgical platforms.[21] The Belmont FMS-2000® (Belmont Instrument Corp, 780 Boston Road, Billerica, MA 01821) has been shown to have maximal fluid heating capability.[22]

Together, convective warming systems and IV blood/ fluid warmers offer optimal core body preservation.[23] These modalities should be universally available to all level II surgical facilities.

Universal Rotary-Wing Transport Capabilities

The proactive, early use of thermal layers in conjunction with a convective warming system will help ensure preservation of body temperature in rotary-wing transport of postoperative patients. Testing and approval of these devices for use in helicopters would be the first step. Making the availability and use of these active warming devices universal in all rotary-winged medical evacuation aircraft within all services would be a major step in minimizing body heat loss during transport.

CONCLUSION

Perhaps the most important area for decreasing the died-of-wounds rates in our combat wounded who reach a facility with surgical capability lies with improving combat damage control surgery.[24] The 2 areas that provide the greatest improvement potential include the treatment and prevention of hypothermia and coagulopathy. All efforts must be made to improve universal measures to improve these areas in level II surgical facilities. Our proactive efforts will be rewarded with a decreased mortality in our combat wounded.

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2006 Spurgeon Neel Writing Competition Winner

Michael Hinton, Executive Vice-President of the Army Medical Department Museum Foundation, has announced that COL Stephen C. Craig of the Uniformed Services University of the Health Sciences (USUHS) in Bethesda, MD, has been selected as the winner of the 2006 Spurgeon Neel Writing Competition. COL Craig, a professor at the USUHS, is the Army Medical Department Consultant in Medical Corps History.

The article by COL Craig, titled "The Evolution of Public Health Education in the US Army, 1893-1966," appeared in the April-June 2006 issue of the *AMEDD Journal*. The article traces the beginning of preventive medicine graduate education in the US Army, and its evolution through the years into what is today the oldest postgraduate medical education program in the military. As the Neel Writing Award winner, COL Craig will receive a $500 monetary prize and a commemorative medallion.

Each year the Army Medical Department Museum Foundation presents the Spurgeon Neel Writing Award to the author of the *AMEDD Journal* article which best exemplifies the history, legacy, and traditions of the Army Medical Department.

The Blood Augmentation Team

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INTRODUCTION

As the rate for those killed in action has decreased, the "died of wounds" rate has understandably increased. Improving the mortality rate of patients undergoing damage control surgical procedures is the largest single area within which we can decrease mortality of injured military personnel in the near future. Our goal should be to raise the capabilities of far-forward surgical facilities (level IIb) to those of civilian level I trauma centers in the management of damage control patients.

On review of capabilities of civilian level I trauma centers and military level III facilities, one significant area that could be improved is blood product availability.[1] Currently, the US Army Forward Surgical Team (FST) is the Army's level IIb facility. Due to the necessity of high mobility associated with clinical austerity, FSTs only carry packed red blood cells (PRBCs). Due to logistic considerations, FSTs do not carry any other blood components like fresh frozen plasma (FFP), cryoprecipitate (cryo), or platelets (PLTs).[2] While the future may see introduction of freeze-dried components (platelets/plasma) that are more easily stockpiled and stored, at the moment the military medical systems should be able to provide some combination of standard component therapy and a system of taking the blood bank to all levels of the battlefield where surgery is expected to occur.

WHY IS BLOOD AVAILABILITY IMPORTANT?

On average, the civilian and combat damage control patient receives between 8 and 12 units of PRBCs.[3,4] In civilian trauma patients there is a severe injury subset of damage control patients who receive over 20 units of PRBCs and civilian trauma centers are reporting improved survival in patients receiving more than 50 PRBCs in the first 24 hours.[5,6] Comparing these numbers with the 20 to 50 units of PRBCs carried by most of our deployed FSTs leads one to conclude that entire blood supply can be exhausted in 2 hours with 1 or 2 damage control patients (eg, all damage control laparotomies should be less than 90 minutes in duration, and FSTs have 2 operating room tables).[7]

In a mass casualty situation the FST, by necessity, will have to go into a "minimal acceptable resuscitation" mode, essentially "triaging" blood supplies.[8,9] By default, these damage control patients will be under-resuscitated. Inadequate resuscitation of a damage control patient can lead to worsening of the patient's acidosis. Acidosis and the often concomitant hypothermia worsen the coagulopathy seen in damage control patients.[10] The coagulopathy leads to more bleeding which causes more acidosis and the vicious cycle of the "lethal triad"—acidosis, hypothermia, and coagulopathy—continues, eventually culminating in exsanguination.

WHY ARE BLOOD PRODUCTS IMPORTANT?

Coagulopathy and acidosis are both predictive factors for death after damage control surgery.[11] Packed red blood cells do not contain clotting factors or platelets. Clotting factors, cryoprecipitate, and platelets are frequently necessary for damage control operations but require special storage considerations. Platelets are stored at room temperature and have an average 5-day storage life after processing.[12] Clotting factors (FFP/ Cryo) are stored at -30^{o}C and thawed before transfusion. In the setting of a damage control procedure or massive resuscitation (defined as 10 or more units of blood in 24 hours), transfusing only PRBCs will not only fail to control coagulopathy or restore platelets (thrombocytopenia), but also can worsen the coagulopathy and thrombocytopenia through dilution of existing clotting factors and platelets in the patient's system.[13-15]

Over 90% of civilian damage control patients receiving 10 or more units of PRBCs also receive FFP, and the majority receive platelet transfusions.[16] The effects of FFP and platelets are maximized if given early during a damage control surgery to stop the coagulopathic process before it feeds into the lethal triad.[17] This concept has been described as hemostatic resuscitation.

The current blood replacement strategy of FSTs is especially problematic in a severe damage control patient by (*a*) inadequate resuscitation and the effect of default acidosis on coagulopathy, and (*b*) dilution of clotting factors and platelets by the transfusion of PRBCs and crystalloid alone. Two current options for FSTs to control coagulopathy involve the use of intravenous Factor VIIa and fresh whole blood.[18] Factor VIIa is not universally available to the FSTs. There is no universal donor for whole blood because this product contains both plasma and red cells. Whole blood must be ABO compatible and transfusing whole blood with the wrong blood type can result in a fatal reaction.[19,20]

While most level IIb sites have performed fresh whole blood transfusions, it is extremely challenging to draw, check for infectious agents, and cross-match whole blood during a damage control operation. The ability to draw fresh whole blood is even more difficult during mass casualty situations with the limited personnel of an FST. While this is challenging even for an established FST with good logistical supply, it would be even more difficult during the maneuver phase of combat when lines of communication are less well established.

HOW CAN WE GET BLOOD AND BLOOD PRODUCTS TO THE FORWARD SURGICAL TEAMS?

To optimize combat damage control and to provide the capability at level IIb sites to correct the abnormal physiology of these critical patients, it is necessary to rethink some of the support issues. In order to bring level IIb facilities up to the capabilities of a civilian level I trauma center, FSTs must have increased ability to transfuse Factor VIIa, FFP, cryo, and platelets. Increased refrigeration space will allow increased PRBCs storage, thawed plasma storage, and safe storage of factor VIIa. The provision of freezer capability and space will allow storage of FFP and Cryoprecipitate. Expert personnel trained in the science of whole blood acquisition and cross-matching will allow the safe transfusion of whole blood for platelet replacement.

Transfusion of FFP and whole blood, in addition to Factor VIIa early during the damage control operation will help proactively correct the coagulopathy of the severely injured trauma patient, and will potentially decrease the PRBC requirement due to decreased coagulopathic bleeding.

Fresh frozen plasma has a shelf storage life of approximately one year. Once thawed, the unit of FFP can be kept as thawed plasma for 5 days in a refrigerator. Over a 5-day period of time, Factor VII levels decrease to 72% of baseline, Factor X decreases to only 80% of baseline, and there is minimal decrease in fibrinogen levels.[21] Thawed plasma offers several benefits over crystalloid solutions in the treatment of hemorrhaging patients. First and foremost, plasma will replace depleted coagulation factors. Second, plasma provides volume and exerts a colloid effect. During World War II and Korea, plasma was the prehospital resuscitation fluid employed by the combat medic.[22] Third, plasma has a more physiologic electrolyte profile than crystalloid. Plasma has a pH of 7.2 to 7.4, compared to the pH of normal saline (4.5 to 6.5), or Ringer's lactate solution (6 to 7.0). Plasma also contributes small amounts of potassium, glucose, lactate, and calcium. The capability to store FFP and thawed plasma at forward levels of care will enhance the ability of the physician to aggressively treat patients with coagulopathy of trauma.

BLOOD AUGMENTATION TEAM

By design the FSTs have limited blood and blood product options. One option for providing increased blood availability and blood products would be the creation of a highly mobile modular team with equipment and expertise in blood transfusion. Such a team could be named a "Blood Augmentation Team" (BAT).

Personnel

We need to look no further than the blood banks at any of our surgical facilities in the United States to find personnel trained in the handling and storage of blood and blood products. These personnel are also experts

in drawing blood, blood cross-matching, and rapid testing of whole blood for transfusion-transmitted infections (HIV and Hepatitis). One or two personnel could fulfill all the blood transfusion needs of an FST. The medical laboratory specialist (military occupational specialty 68K) performs blood banking procedures and elementary and advanced examinations of biological and environmental specimens to aid in the diagnosis, treatment, and prevention of disease and other medical disorders, according to a structure of defined skill levels:

- Skill Level 1. Performs elementary clinical laboratory and blood banking procedures.
- Skill Level 2. Performs elementary blood banking and clinical laboratory procedures in hematology, immunohematology, biochemistry, serology, bacteriology, parasitology, and urinalysis.
- Skill Level 3. Performs advanced procedures in all phases of blood banking and clinical laboratory testing including virology, mycology, toxicology, and histology or supervises small medical laboratory.
- Skill Level 4. Supervises medium size medical laboratory.
- Skill Level 5. Supervises large medical laboratory activities.

Mobile Platform

The first requirement of the BAT will be mobility which matches that of the FSTs. This could be met with an armored wheeled vehicle (initially an armored HMMWV*). The vehicle must have refrigeration, freezers, and all of the equipment needed for field expedient blood cross-matching and rapid testing of whole blood. These components would require the capability to generate electricity for periods of travel between sources of electricity. The next refinement would be the capability to transfer these components onto any helicopter or fixed wing aircraft that might be transporting the FST.

Capabilities

The BAT would have the capability of increased PRBC availability. It would also have the capability to cross-match and provide FFP, Cryoprecipitate, platelets, and rFVIIa. While the FST personnel are fully engaged during a mass casualty situation, the unit would handle the drawing and cross-matching/testing of whole blood if needed.

The bottom line: the BAT could enhance the capability of the FST to perform combat damage control surgery to the level of a civilian level I trauma center and to potentially help decrease the mortality rate of these patients.

IMMEDIATE FUTURE

While it will take time to create and to accumulate the correct equipment for the Blood Augmentation Team, in the short term we can enhance the ability of FSTs to correct the coagulopathy seen in damage control patients by adding thawed plasma and rFVIIa to the inventories of all far forward surgical platforms.[23-26] The addition to the FST of a single blood bank Soldier will allow safe storage of all blood and the safe drawing and cross-matching of whole blood (this concept was validated in Operation Enduring Freedom in 2002).

CONCLUSION

The Blood Augmentation Team will bring banking expertise and material to the battlefield. As more "shelf stable" blood product replacements come into the armentarium of the combat physicians, nurses, and medics, the Blood Augmentation Team will have to evolve, providing a dynamic platform for rapid fielding of these advances.

*High mobility multipurpose wheeled vehicle

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Optimizing Transport of Postoperative Damage Control Patients in the Combat Zone

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INTRODUCTION

One area of potential improvement in mortality in the combat zone is the patient undergoing damage control at a level IIb (eg, Forward Surgical Team) or level III surgical facility.[1] One major difference between damage control surgery in the civilian trauma centers and military combat damage control surgery is the air evacuation after the "abbreviated" operation of the damage control trilogy at military surgical facilities. Another major difference is that combat damage control patients at level II are often not optimally resuscitated due to limited blood supply and lack of stored blood products (eg, fresh frozen plasma and platelets).[2,3] The lethal triad of hypothermia, acidosis, and coagulopathy represent the greatest challenge to postoperative combat damage control patients undergoing rotary-wing air evacuation.[4] Currently, very few interventions are possible during helicopter transport of these critically injured patients due to wide variations in personnel, personnel training, helicopter setup, and inflight conditions. De Lorenzo stated in 1997 that "Improved combat casualty care and battlefield survival may be possible by increasing both the number and training of the medical attendants on Army aircraft."[5]

The combat surgeon often hopes that the patient will arrive alive at the level III facility without irreversible physiologic perturbations to undergo completion of the resuscitation phase of damage control. Optimization of these critically ill patients during transport is an important strategy to increase survival on the battlefield, replacing hope with capability.

CURRENT COMBAT AIR EVACUATIONS

Currently, military doctrine dictates several variable, nonstandard platforms for intratheater air evacuation of severely injured postoperative damage control patients (traveling from level II to level III or level III to level III), most commonly UH-60 Blackhawk, CH-47 Chinook, or CH-46 Sea Stallion helicopters. Medical crewmembers in the aircraft likewise vary in training and experience, typically an Army 68W Medic or Navy Corpsman (usually EMT–B).[6] Larger Marine Corps aircraft might also include flight nurses. Personnel training, experience, and capabilities vary widely, not only between units, but also amongst services. Monitoring with the PROPAQ® (Welch Allyn, Inc, 8500 SW Creekside Place, Beaverton, OR 97008) equipment is noninvasive but is significantly limited by aircraft configurations and combat logistics. Thermoregulation is currently maximized by using a number of commercial and improvised methods, such as placing the patient in a modified body bag with 2 wool blankets, and a reflective blanket.

CURRENT CIVILIAN TRANSPORT OF CRITICAL POSTOPERATIVE PATIENTS

Transport of critically ill patients after damage control surgery in a level 1 trauma center usually involves intrahospital transport, including movement to a radiology suite (eg, computed tomography or interventional). At a minimum, transport typically involves escort by a critical care nurse and respiratory therapist. If the patient is going to the operating room, a certified registered nurse anesthetist (CRNA) and/or an anesthesiologist will also accompany the patient.

Civilian helicopter air ambulance crews transporting critically injured patients usually include a combination of at least 2 heath care providers, usually including a paramedic (EMT-P) teamed with a registered nurse, respiratory therapist, another paramedic, or a physician.

Defining Optimal Conditions For Rotary-Wing Transport Of Postoperative Damage Control Patients

When defining the optimal personnel and equipment for transporting postoperative patients, the first step is to define the potential complications and risks that could arise in flight, placing the transported patient at risk for injury or death.

Risks To Postoperative Patients During Air Evacuation

The following are potential risks, some catastrophic, to the severely injured and ventilator dependent postoperative damage control patient during helicopter air evacuation:

Severe Hypothermia. Hypothermia (especially core body temperature <34°C) is a marker and predictor of death after damage control laparotomy and is associated with increased bleeding, blood transfusion, and intravenous fluid requirements.[7-12] The importance of prevention and amelioration of hypothermia en route to a level III facility cannot be overstressed. Currently, temperature is not monitored inflight during patient transport.

Exsanguination. Patients with a vascular shunt in place or a guillotine amputation can have catastrophic resumption of arterial hemorrhage with a misplaced shunt or blowout of arterial clot and ligature. Continued coagulopathic truncal bleeding in the postoperative damage control patient is the norm and not the exception, especially if the patient has not received any coagulation factors, factor VIIa, or whole blood.[13]

Lack of Adequate Monitoring During Flight. The postoperative damage control patient requires minute-to-minute monitoring of heart rate, oxygen saturations, and blood pressure. Lead placement malfunction, inadequate battery recharge, and monitor mechanical failure can all result in inadequate or complete lack of inflight patient monitoring. Inadequate view of the monitor by accompanying medical personnel results in inadequate monitoring.

Loss of Airway or Endotracheal Tube. Loss of the patient's airway or dislodgement of an endotracheal tube is always a possibility, especially with patient movement and the erratic helicopter movement often necessary in a combat zone. Airway management and the rate of successful intubation are clearly documented to be directly related to the amount of training obtained at the EMT level.[6,14,15]

Loss of Intravenous Access. Loss of central or peripheral intravenous access during air evacuation could be life threatening to a patient requiring inflight fluid/blood replacement or from blood loss from disconnected IV tubing.

Ventilator Malfunction. Ventilators, like all machines, are prone to malfunction, especially those exposed to dust and temperature extremes. Inadequate battery charge level can, of course, also cause a ventilator to cease operating.

Symptomatic Pneumothorax. Level II facilities do not have the capability to perform routine postoperative chest x-rays. A clinically significant pneumothorax can be delayed until the patient is airborne (especially with gas expansion at altitude in a fixed-wing aircraft). This condition can be extremely confusing to diagnose and treat, especially if the patient has multiple potential sources of hypoxia and/or hypotension.

Inadequate Sedation/Analgesia. Intravenous sedation and analgesia, a continuous process, includes observation and timely administration of sedative/pain medications which, if not adequate, can result in patient self-extubation and removal of life-sustaining lines, tubes, etc. This can be a lethal complication during flight. Inadequate sedation and recall could contribute to posttraumatic stress disorder in trauma patients.[16]

Inadequate Oxygen Supply. There are reports of ventilated patients arriving at a level III facility without having received oxygen supplementation due to inadequate oxygen supply on the rotary-wing aircraft. Inadequate oxygen supply can be of great

significance to the oxygen dependent, severely injured, ventilated postoperative damage control patient.

Optimal Critical Care and Contingency Plans for Inflight Complications

Severe Hypothermia. Multiple layers, as represented by the body bag/wool blanket/reflective blanket combination, have been documented as an effective means to preserve body heat.[17] The addition of a convective heating device has been documented as providing optimal body heat preservation in transported and perioperative patients.[18-21] Optimal thermoregulation of patients transported in a helicopter may be obtained with the testing (for helicopter safety) and approval of the use of a convective warming system (eg, Bair Hugger®, Arizant Healthcare Inc, 10393 West 70th Street, Eden Prairie, MN 55344) within the insulating layers, or the combination of multiple layers, skull cap, and use of a chemical heat generating device (Hypothermia Prevention and Management Kit NSN# 6515-01-532-8056).

Exsanguination. The majority of patients who are postoperative from a damage control surgery are packed and have been (by logistic necessity) minimally resuscitated with PRBCs and crystalloid only, and will have some degree of coagulopathic bleeding.[3,13] Over time, the cumulative effect of this blood loss may be profound hypotension and further exacerbation of coagulopathic hemorrhage. The ability to infuse further PRBCs during flight will potentially extend the duration until irreversible exsanguination.[22] All medical personnel accompanying patients with extremity temporary intravascular shunts in place or postoperative after an amputation must be trained in the rapid application of tourniquets and, of course, must also have immediate access to a tourniquet. Optimally, patients with a truncal (or proximal extremity vascular shunt not amenable to tourniquet placement proximally) temporary intravascular shunt in place should be accompanied by a surgeon with immediate access to a vascular clamp.

Lack of Adequate Monitoring During Flight. Postoperative damage control patients need continuous monitoring. Loss of this monitoring could be catastrophic while airborne. Personnel must be trained to correct any small malfunctions and redundancy should be built into inflight capability (including redundant electrical supply). Continuous blood pressure monitoring can only be obtained by intra-arterial monitoring and should be incorporated into the care of all transported postoperative damage control patients in the near future, with redundancy provided by noninvasive blood pressure cuff monitoring.

Loss of Airway or Endotracheal Tube. Personnel transporting intubated postoperative damage control patients must be highly trained in airway management.[23] Skills should include excellent bag mask ventilation, inflight reintubation, and cricothyroidotomy (surgical airway).

Loss Intravenous Access. Loss of intravenous access in the hypovolemic and hypotensive postoperative patient or the patient with fluid and vasopressor dependence could be catastrophic. Obtaining common inflight venous access is extremely difficult. One excellent option for obtaining inflight venous access is intraosseous sternal venous access. These skills and equipment should be available to all personnel transporting these postoperative patients.[24,25]

Ventilator Malfunction. Ventilator malfunction during flight could be catastrophic. Personnel monitoring these patients must be able to diagnose ventilator malfunction (and have a redundant electrical source), be able to troubleshoot the machine and, as a default, be able to hand-bag the patient. Hand-bagging a patient correctly, especially one with a head injury, can be very difficult.[26] The addition of end tidal CO_2 monitoring may optimize ventilator and hand-bagging of postoperative patients and should be considered for the armentarium of inflight medical aircrew personnel as soon as possible.[27]

Symptomatic Pneumothorax. Diagnosing a tension pneumothorax in a postoperative damage control patient during flight in a helicopter can be extremely difficult. Low saturations and a high peak airway pressure on the ventilator may be the only clues available as inflight auscultation is nearly impossible. Medical personnel accompanying these patients should be trained in the diagnosis and treatment of tension pneumothorax, including needle decompression and chest tube placement.[28]

Inadequate Sedation. Accompanying medical personnel must be trained in the signs of inadequate sedation and administration of sedative medications.

Adequate supply of sedative medications must be part of a preflight medical checklist.

Inadequate Analgesia. Accompanying personnel must be trained in the signs of inadequate pain control, the continuous monitoring for signs of pain, and timely administration of intravenous pain medications. An adequate supply of sedative medications must be part of a preflight medical checklist.

Inadequate Oxygen Supply. Adequate oxygen and an extra volume of oxygen as a redundancy should be part of every preflight medical checklist.

FUTURE OPTIMAL TRANSPORT

In the perfect scenario, the postoperative combat damage control patient would be transported between surgical facilities in a rotary-winged aircraft with capabilities approaching that of the USAF Combat Casualty Air Transport Team, which has demonstrated efficacy in the safe out-of-theater transportation of critically injured military personnel by fixed-wing aircraft.[29]

OPTIMAL ROTARY-WING AIRCRAFT

The patient would be transported on an elevated platform with 360° access. The helicopter cabin would be shut and auxiliary heaters would heat the cabin (currently, most helicopters are flown with the doors open to allow for door gunner security). A convective heating system, wall suction, and oxygen would be available from the aircraft. The helicopter would be armored with new weight-limited material. Many of these capabilities will be found in the HH-60L/M (new Blackhawk medical variant). Until an optimal aircraft designated for evacuation is fielded, it may be necessary to approach the optimal conditions with additional mobile component equipment.

OPTIMAL PERSONNEL

Due to onboard space limitations, a CRNA, anesthesiologist, general surgeon, or emergency medicine physician would be responsible for the endotracheal tube, ventilator, and fluid/blood/vasopressor administration. These personnel are the most experienced at airway management and resuscitation. A highly trained registered nurse or a team consisting of a highly trained paramedic or flight medic trained specifically for inflight complications, accompanied by a respiratory technician or nurse, could potentially have similar capabilities. These nurses, flight medics, and/or paramedics would need extensive airway skills and would need significant time in specific training at a facility in the United States.[30] These personnel would be used in the transportion of only critical postoperative damage control patients.

OPTIMAL EQUIPMENT

The optimal equipment for helicopter evacuation would include a convective warming system for all postoperative patients. Monitoring would include continuous intraarterial monitoring and end tidal CO_2 analysis. Storage of PRBCs and a fluid warmer system would be available. Surgical equipment would be available for needle decompression, chest tube placement, and cricothyroidotomy. Ventilators would have the capability to measure peak airway pressures. Intraosseous access equipment would be available. Preflight medical checklists would ensure built-in monitoring/battery redundancy and adequate oxygen supplies, sedation medications, and blood.

CONCLUSIONS

Current capabilities of helicopter medical crewmembers and equipment transporting critically injured postoperative combat damage control patients are limited. Using the inexperienced paramedical provider for the sole care of the patient does not provide optimal care to those patients who are the highest acuity battlefield casualties.

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COL BARRY MOORE AND MAJ TERESA BRININGER JOIN THE *AMEDD JOURNAL* EDITORIAL REVIEW BOARD

The *AMEDD Journal* welcomes COL Barry Moore, DC, USA and MAJ Teresa Brininger, SP, USA as new members of the Editorial Review Board. COL Moore is the Chief, Department of Dental Science, AMEDD Center & School, Fort Sam Houston, Texas. MAJ Brininger is a Research Occupational Therapist at the Army Research Institute of Environmental Medicine, Natick, Massachusetts.

COL Moore joins the Board replacing COL Thomas R. Cole, DC, USA. COL Cole is an original member of the Board, accepting his position in November, 1999. We thank COL Cole for his dedication to the high standards and professional quality of this publication, and his years of service and support to our mission.

MAJ Brininger replaces LTC Rachel Evans, SP, USA who has accepted the position of Director, Amputee Research Program at the Center for the Intrepid, Fort Sam Houston, Texas. LTC Evans has been a member of the Editorial Review Board since 2002. We thank LTC Evans for her dedication and support of the *AMEDD Journal* and congratulate her for her profoundly important new assignment.

The Editors

Management of Traumatic War Wounds Using Vacuum-Assisted Closure Dressings in an Austere Environment

LTC M. Shaun Machen, MC, USA

ABSTRACT

Objective: The study was undertaken to develop a protocol for the ongoing management of traumatic war wounds in the austere environment of a combat support hospital.

Method: A total of 286 surgical procedures were performed by a single orthopaedic surgeon during a 5-month period at a combat support hospital in Iraq. Over 150 procedures were performed on Iraqi soldiers, detainees, and civilians who would receive their definitive care at the combat support hospital, and who would remain as inpatients until their wounds were healed enough for discharge. Initially, all extremity wounds were treated with surgical irrigation and debridement followed by twice daily dressing changes on the wards. As the ward census increased to 75 patients, it became necessary to develop alternate forms of wound management. Field expedient vacuum-assisted closure (VAC) dressings were instituted. These dressings were created with fluffs or prep sponges, suction tubing, Ioband™, and portable suction machines. The VAC dressings were left in place for 3 to 4 days and then changed. Traumatic, contaminated, and infected wounds were rapidly debrided and granulation tissue was induced. The portable suction pumps, however, were extremely noisy and failed with continued use. Machines and sponges manufactured by KCI Inc. were purchased. The VAC dressing became an invaluable tool for managing, closing, and preparing wounds for skin grafting. Over 50 traumatic war wounds were treated with the VAC dressing. The clinical courses of 20 of these wounds were carefully documented with digital photography.

Results: Over 50 traumatic war wounds were effectively treated with initial irrigation and debridement, followed by serial application of VAC dressings. VAC dressings rapidly debrided contaminated wounds, reduced edema, decreased wound size, and induced granulation tissue. Wounds were then treated by delayed primary closure, local flap coverage, or skin grafting.

Conclusion: An effective protocol utilizing VAC dressings was developed for the expeditious treatment of traumatic war injuries in an austere environment.

INTRODUCTION

A total of 286 surgical procedures were performed by a single orthopaedic surgeon during a 5-month period at a combat support hospital (CSH) in Iraq. The vast majority of injuries treated were combat related—gunshot wounds and fragment injuries from mortars and improvised explosive devices. Injuries treated included contaminated soft tissue injuries, open fractures, open joints, and traumatic amputations.

Over 150 procedures were performed on Iraqi soldiers, detainees, and civilians who would receive their definitive care at the CSH, and would remain as inpatients until their wounds were healed sufficiently for discharge. Initially, all extremity wounds were treated with surgical irrigation and debridement, fracture stabilization, followed by twice daily wet to dry dressing changes on the wards. As the war escalated and the hospital census increased to 75 patients, twice daily dressing changes became logistically difficult. The development of alternate forms of wound management was necessary.

Vacuum-assisted closure, initially developed in the 1990s for the management of large, chronically

infected wounds[1] has more recently been used in the treatment of traumatic wounds.[2] The modality creates a wound environment of subatmospheric pressure which reduces interstitial fluids, removes debris, contracts the wound, enhances blood flow to the wound, and promotes the formation of granulation tissue. The VAC dressing can be applied in the operating room after debridement and conveniently left in place for 3 to 4 days.

The purpose of this study was to develop a wound treatment protocol to effectively manage a large number of traumatic war injuries in a combat environment. A "field expedient" VAC dressing was initially used, and later replaced by commercial V.A.C.® ATS® Systems (Kinetic Concepts, Inc., San Antonio, Texas) when they became available in the military supply system.

MATERIALS AND METHODS

The initial VAC dressings used at the CSH were created from available materials in the austere environment of a combat support hospital. Following thorough irrigation, debridement, and fracture stabilization—usually with an external fixator—a field expedient VAC dressing was applied. As shown in Figure 1, the dressing was created by placing either lap sponges or yellow preparation kit sponges in the base of the wound. The skin edges were cleaned and defatted with an alcohol wipe. The end of a standard suction tube was fenestrated with holes created with a scalpel and was placed within the sponges. An Ioband™ adhesive drape was then used to cover the sponges and wound, and a "mesentery" was formed around the tube. The tube was then connected to a portable bedside suction machine on low, intermittent suction.

The improvised VAC systems worked relatively well, but some problems were identified. Inevitably, when the yellow prep sponges were used there were areas of the wound that were not in contact with a sponge. These areas developed a mucinous, exudative slime over the course of 3 days. The improvised tubes would occasionally become plugged or collapse, and the wounds would not contract as well as they do with one large, uniform sponge pulling the edges together. The biggest problems experienced involved the portable suction machines. The machines were very noisy and disrupted the sleep patterns of patients packed into tight wards. Wool blankets and cardboard boxes were placed over the machines to reduce the noise, but this contributed to overheating and the machines would fail. With high ambient temperatures and continuous use, all of the machines eventually failed. Our ability to use VAC dressings became limited by the nonavailability of suction machines.

As soon as the problem with suction pumps was identified, a rush order was placed to Kinetic Concepts, Inc. for 5 V.A.C. ATS systems as well as a large supply of black sponges of various sizes. The V.A.C. ATS is a subatmospheric pressure device that uses a medical grade reticulated polyurethane ether sterile foam dressing, which contains an embedded noncollapsible evacuation tube. The pore size of the sponge is 400 µm to 600 µm, which has been shown to maximize tissue ingrowth,[3] and the tube contains side ports to allow communication of its lumen to all the spaces in the foam. The V.A.C. ATS pump itself has technology which allows accurate pressure sensing, adjustable pressure intensity, intuitive touch screens, filter system to minimize wound odor, and quiet operation. The arrival of this medical equipment greatly enhanced our ability to effectively treat even the most gruesome battle injuries.

A protocol was developed: All battle injuries undergo initial irrigation via pulsatile lavage, debridement of all foreign material and devitalized tissue, and external fixation of fractures. An attempt is made to preserve all large fracture fragments, smaller fragments with soft tissue attachments, and tendons. A sterile gauze

Figure 1. A field-expedient VAC dressing created with a lap sponge and Ioband.

Figure 2. A sterile black foam dressing is cut to fit the contour of the wound.

dressing is applied. On post-op day one, the patient undergoes a dressing change on the ward, with Ketamine sedation if necessary. On post-op day two, the patient returns to the OR for repeat irrigation and debridement, and placement of a wound VAC. The sponge is trimmed and shaped to contact all wound surfaces allowing equal distribution of the subatmospheric pressure to all surfaces in contact with the sponge (Figure 2). The skin along the edges of the wound is cleaned and defatted with alcohol, the noncollapsible tube is placed, and the wound sealed with an adhesive drape supplied with the sponge (Figure 3). We are careful to trim back the edges of the adhesive drape, while still maintaining a seal, to prevent abraded or fragment injured skin from becoming exudative. Finally, the tube is connected to the pump and the suction adjusted to between 50 mm and 125 mm Hg. The pump is turned on and the dressing is tested to make sure that the sponge collapses into the wound (Figure 4).

Figure 3. The VAC sponge is sealed into the wound with the adhesive drape.

The VAC dressing is left in place for 3 to 4 days and is either changed in the operating room depending on what other procedures are needed, or changed on the ward under Ketamine sedation. VAC dressings are changed every 3 to 4 days until the wound is prepared for definitive closure. Typically the wound contracts as edema is removed and the wound edges are pulled together. The wound becomes very clean and free of exudative fluids. Vascularity is enhanced and beefy red granulation tissue forms (Figure 5). Wounds are then closed either by delayed primary closure, local rotational flaps, or split thickness skin grafts, illustrated in Figure 6.

The wound VAC was used on a variety of upper extremity, lower extremity, and even torso wounds. All wounds treated were secondary to gunshot, fragmentation, or blast. The VAC was placed over muscle, tendons, fasciotomy sites, limb amputations, exposed bone (Figure 7) and even orthopaedic

Figure 4. Suction is applied to the sponge and the adhesive drape is trimmed to minimize skin

hardware. Several patients with infected stumps, resulting from amputations which had been performed elsewhere, were treated with the VAC (Figure 8). The VAC was placed on at least 50 combat casualties. The course of wound VAC therapy on 20 cases was thoroughly documented from initial wound to fully healed wound with digital photographic records.

CASE ILLUSTRATION

A 43-year old Iraqi enemy prisoner of war sustained a fragmentation injury to his left nondominant elbow. The fragmentation injury resulted in a type 3B olecranon fracture with bone loss and extensive soft tissue injury (Figure 9). The soft tissue injury involved skin loss in a 10 cm by 20 cm area involving the entire

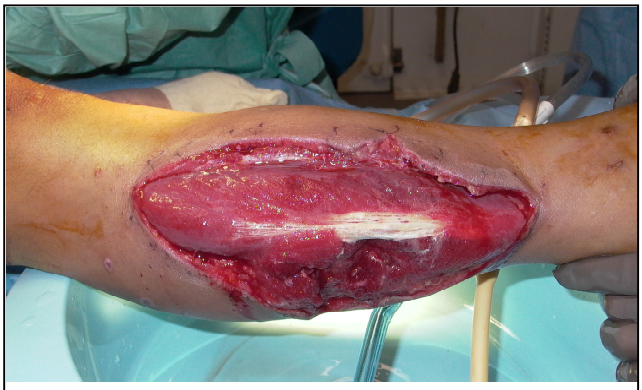

Figure 5. Wound appearance after 3 days of wound VAC treatment.

Figure 6. One week after application of skin graft to wound.

Figure 7. Accumulation of granulation tissue on exposed bone and hardware.

Figure 8. A VAC sponge is applied to the residual limb of an infected above the knee amputation.

Figure 9. Type 3B olecranon fracture with extensive soft tissue and bone loss.

Figure 10. Wound VAC in place.

Figure 11. Wound appearance after 12 days of VAC treatment.

posterior aspect of his elbow. The wound was treated with initial pulsatile irrigation and debridement. The patient was returned to the operating room 2 days later for repeat irrigation and debridement followed by placement of a wound VAC (Figure 10). Wound VAC treatment continued for 12 days with VAC changes every 4 days. On post-injury day 14, the wound had a healthy, clean appearance (Figure 11). The wound VAC treatment had resulted in the reduction of edema, and the formation of beefy red, well-vascularized, granulation tissue. A split thickness skin graft was harvested and placed over the wound (Figure 12). The skin graft was 100% successful. The wound healed and the patient was discharged. The patient returned for followup 2 months after injury. As shown in Figure 13, the wound was completely healed. The patient was taken to the operating room and manipulation under anesthesia was performed to increase range of motion. A functional range of motion was achieved on the operating room table.

Figure 13. Wound area 2 months after injury.

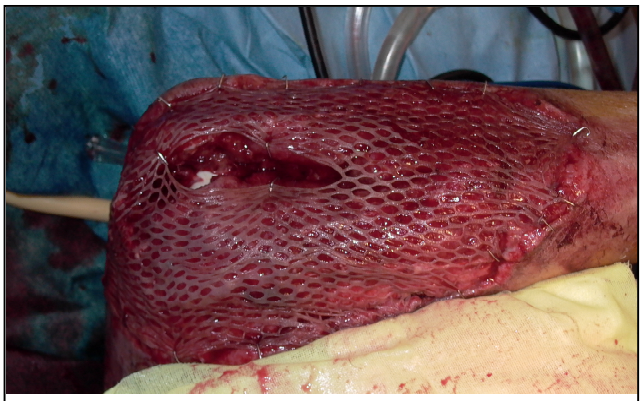

Figure 12. Wound after placement of split thickness skin graft.

RESULTS

The wound VAC evolved into an extremely useful modality for the treatment of high-energy combat wounds. The period of time during which this device was used was one of intense fighting and high casualty rates. The wound VAC was applied rapidly, either in the operating room after irrigation and debridement, or on the ward with Ketamine sedation. The VAC dressing could then be left in place for 3 or 4 days, greatly diminishing the need for painful, time-consuming dressing changes and multiple trips to the operating room. With only one orthopaedic surgeon assigned to the CSH during a 5-month period, this device greatly increased productivity and freed the surgeon to attend more critical patients.

Wound VAC treatment was used on over 50 patients. Digital photography with dates and times were obtained to document stages of treatment and healing in 20 cases. Four infected above-knee amputation stumps were treated and effectively closed or skin grafted after VAC use. Three open both-bone forearm fractures secondary to through and through gunshot wounds (GSW) were plated, treated with wound VAC, and skin grafted. Four Type 3B open distal tibia/fibula fractures secondary to GSW were treated with external fixation, wound VAC, tibial shortening in one case, local rotational flap or skin graft, and finally bone grafting (Figure 14). An open subtrochanteric femur fracture, secondary to GSW, with thigh compartment syndrome was treated with fasciotomy, fracture stabilization with a Rush Rod, 90/90 traction, wound VAC, and delayed primary closure. The patient was discharged to crutch weight bearing after 3 weeks of traction. Two open proximal humerus fractures and

Figure 14. Type 3B tibia fracture secondary to gunshot wound, treated with external fixation, wound VAC, tibial shortening, and local skin flap.

one open distal humerus fracture were all effectively treated with external fixation or open reduction internal fixation followed by wound VAC and skin grafting. A GSW to the plantar surface of the foot, 2 large soft tissue injuries to the thigh, and one GSW to the buttock were all treated with wound VAC followed by healing by secondary intention, or delayed primary closure and skin grafting.

Problems associated with the earlier described field expedient VAC dressings were essentially solved by the V.A.C. ATS systems. As we developed greater expertise in the use of the system, we learned, especially in the case of amputations, to make sure that no areas of dead space existed when the sponges were placed over large wounds. We also learned to leave no area of raw wound uncovered by sponge material. Suction was applied, and the dressing was trialed in the operating room. If an area of wound was uncovered, the adhesive drape would be cut, a small portion of sponge would be inserted over the exposed wound, and the dressing would be resealed. Maceration would occur in cases where the adhesive drape did not completely seal to the skin on the borders of the wound. To prevent this, we used alcohol to thoroughly clean, defat, and dry the skin prior to application of adhesive drape. The problems encountered with the VAC dressing were really minimal. More often than not, we were amazed at the clean, healthy appearance of the wounds when the dressings were removed.

DISCUSSION

Treatment of combat related orthopaedic wounds, which are often complicated by large skin loss, devitalized tissue, gross contamination, open fractures, and infection secondary to treatment delay, is complicated. The treatment difficulty is compounded when the treatment must occur in the austere environment of a combat "tent" hospital, in a war zone, with limited supplies, and large numbers of patients. This paper describes a technique that evolved and a protocol that was established to efficiently manage the wound care of large numbers of combat casualties. The V.A.C. ATS proved extremely valuable in accelerating the healing of 20 documented traumatic wounds.

The ability to obtain eventual soft tissue coverage in the wounds studied was attributed to a number of different factors:

a. Because of the negative pressure acting on the sponge, the interstitial fluids that accumulated in these wounds were evacuated. These fluids have been found to contain inhibitory factors such as inflammatory cytokines and collagenases that suppress the formation of fibroblasts, vascular endothelial cells, and keratinocytes that are prominent in wound healing.[3-5]

b. The evacuation of these fluids eliminates the formation of any superficial purulence and slime that occurs in open wounds.[1] This enhances wound healing by reducing the potential for anaerobic colonization, and decreasing bacterial counts.[6]

c. Studies have demonstrated that an applied subatmospheric pressure results in decreased capillary afterload.[1,6] This decreased afterload allows arterioles to dilate, increasing blood flow to the area fourfold. Increased blood flow produces a proliferation of granulation tissue.

d. The negative pressure created by the vacuum exerts a mechanical force to the soft tissues that make up the periphery of a wound. Unlike sutures or tension devices, the VAC can exert a uniform force on each individual point on the edge of a wound, drawing it toward the center of the defect by mechanically stretching the cells via the application of negative pressure.[6]

e. The labor involved and the pain associated with frequent wet to dry dressing changes is minimized.

While other published studies have attempted to quantify wound size reduction with VAC treatment, or have investigated the costs of treatment compared with conventional wound care, this study was more observational in nature. Our measure of a successful outcome was achieving a healed, noninfected wound, in an austere environment, with limited supplies, and the nonavailability of plastic surgeons. This is the first study that describes the use of subatmospheric dressing technology to treat high-energy ballistic wounds in a combat environment. We have shown that VAC systems can be successfully used to treat large numbers of patients in a highly effective and efficient manner. It is recommended that V.A.C. ATS systems become part of the inventory of all combat support hospitals tasked with managing large numbers of combat patients for extended periods of time. Subatmospheric pressure dressings are an excellent adjunct in the effective and safe treatment of high-energy, combat, orthopaedic wounds.

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Causes of Death in US Special Operations Forces in the Global War on Terrorism: 2001–2004

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ABSTRACT

Introduction: Effective combat trauma management strategies depend on an understanding of the epidemiology of death on the battlefield, resulting in evidence-based equipment, training, and research requirements.

Methods: All Special Operations Forces (SOF) fatalities (combat and noncombat) in Operation Iraqi Freedom/Operation Enduring Freedom (OEF/OIF) from October 2001 until November 2004 were reviewed. All available autopsy and treatment records and photographs were used. In most cases, the immediate tactical situation was unknown. The review was performed by a multidisciplinary group including forensic pathologists, an SOF combat medic, and trauma surgeons. Fatalities were classified as having wounds that were either nonsurvivable or potentially survivable with existing training, equipment, and expertise on the battlefield. A structured review was performed evaluating the need for new equipment, training, or research requirements. Results were compared to autopsy data from Vietnam and modern civilian trauma center data. The study was approved by the Institutional Review Boards of the Armed Forces Institute of Pathology and the US Army Institute of Surgical Research.

Results: During the study period, 82 SOF fatalities were identified. Autopsies were performed on 77 Soldiers. Five casualties died secondary to aircraft crash, their bodies were not recovered from the ocean. For the purposes of this study they were considered nonsurvivable. Eighty-five percent (n=70) of the fatalities sustained wounds that were nonsurvivable, while the remaining 15% (n=12) had wounds that were potentially survivable. Injury Severity Score (ISS) was higher in the nonsurvivable group ($p<0.05$). Truncal hemorrhage accounted for 47% of deaths while extremity hemorrhage accounted for 33%. One casualty was noted at autopsy to have a tension pneumothorax as well as multiple sources of internal hemorrhage, one suffered an airway death, while another died of sepsis 56 days after injury. Of those casualties deemed to be nonsurvivable, there were 31 patients with 40 Abbreviated Injury Score (AIS) 6 injuries ($p=.0011$), and 53 patients with 104 AIS 5 injuries. Among the 12 deaths deemed to be potentially survivable, there were only 8 AIS 5 injuries. Deaths were largely caused by explosions (n=35), gunshot wounds (n=23), and aircraft accidents (n=19). No new training or equipment needs were identified for 53% of the potentially survivable deaths while improved methods of truncal hemorrhage control need to be developed for the remainder. The review panel concluded that 85% of the deaths would not have been prevented at a civilian Level I facility. Available records, in most cases, did not contain information about the use of body armor, time to death after injury, or the ongoing tactical situation.

Conclusions: The majority of deaths on the modern battlefield are nonsurvivable. Current results are not different from previous conflicts. In Vietnam, reported potentially preventable death rates range from 5% to 35% and civilian data reports potentially preventable death rates ranging from 12% to 22%. Military munitions cause multiple lethal injuries. Current trauma training and equipment is sufficient to care for 53% of the potentially survivable deaths. Improved methods of intravenous or intracavitary noncompressible hemostasis combined with rapid surgery are required for the remaining 47% of the decedents.

INTRODUCTION

Identifying areas for improvement in modern combat trauma management depends on a clear understanding of the epidemiology and outcome of combat injuries. Thus, an important prerequisite to optimize the treatment of injured combatants is the ability to analyze current data so that new strategies of care, equipment requirements, and a focused research agenda can be changed to meet contemporary goals and needs. Analyses of deaths from injury have long been a cornerstone of trauma system development and are essential to measure improvements of civilian systems of trauma care.[1,2] Equivalent studies have occurred on several military data sets.[3-5]

Previous analysis of US combat deaths largely rests in the analysis of Vietnam casualties described by the Wound Data and Munitions Effectiveness Team (WDMET) database. This analysis is now 40 years old and has served to drive military medical research, logistics, and medical tactics since that time. Changes in body armor, improved medical care, equipment, and training common to the current war versus Vietnam raises the question of the applicability of the WDMET data to the current experience. An additional and perhaps more important concern about the WDMET applicability stems from the current methods of death analysis, derived from 30 years of experience in maturing trauma systems research.[6]

We hypothesized, based on improvements in body armor, medical care, equipment, and training, and an improved understanding of appropriate death analysis, that different patterns of potentially survivable injuries would emerge, leading to new research and interventions. The goal of this review was to identify those injuries that were potentially survivable, were amenable to current prevention and treatment modalities, or required new treatment and training capabilities, or research. The resulting data was compared to previously published data from civilian and military trauma autopsy studies.

METHODOLOGY

All recovered remains of US combatants are transported to Dover, Delaware, where complete identification and forensic examination is performed by the Office of the Armed Forces Medical Examiner. These unique resources form the basis for this report. Institutional Review Board approval for the study was provided by the US Army Institute of Surgical Research and the Armed Forces Institute of Pathology.

All SOF fatalities were identified by the personnel office of the US Special Operations Command. This included both combat and noncombat fatalities and those killed in action, as well as those who died of wounds.[7] Treatment records and files from the Joint Theater Trauma Registry and the Office of the Armed Forces Medical Examiner were compiled and unique identifiers removed for this review. The study team included forensic pathologists, military and civilian trauma surgeons, a trauma nurse, and a Special Operations combat medic.

Historically, the majority of combat deaths are beyond salvage.[4] A screening review using autopsy information to estimate the severity of injury and suddenness of death was performed to identify cases that merited a detailed evaluation. As in previous wars, the severity and multietiology, multisystem injury in combat is such that detailed review was not warranted in most cases.

Patients were classified as either nonsurvivable or potentially survivable against a standard of the deployed US level III medical treatment facilities in theater. These level III facilities represent the highest standard of medical care available in the deployed setting. This standard was chosen with full understanding of the extreme variability of the tactical, geographic, and logistical environment of combat injury, and thus the lack of ability to normalize care for a single individual casualty. The commonly used civilian morbidity and mortality category of preventable was not used as the tactical situation was not known, thus medical judgments of preventable in the absence of tactical knowledge were deemed unacceptable. All patients for whom autopsies were available had been coded independently for Abbreviated Injury Score (AIS) and Injury Severity Score (ISS). A structured review and analysis of each case was completed to determine where opportunities for improved outcome existed. Areas that were a prime consideration in this questionnaire involved equipment, training, expedient evacuation, body armor, Tactical Combat Casualty Care (TCCC) guidelines,[8] and new research requirements. Not all of the data required to completely answer each question was available. For example, whether or not the

casualty was wearing personal protective equipment (PPE) or whether PPE would have prevented the wound from being sustained was often difficult to ascertain.

RESULTS

There were 82 SOF fatalities with 77 autopsies; from 35 explosions (42%), 23 gunshot wounds (GSW) (28%), 19 from aircraft crashes (23%), 4 motor vehicle crashes, and 1 fall (Table 1). The numbers differ somewhat from observations throughout OEF/OIF. Compared to conventional Soldiers, the SOF fatalities have a higher incidence of death secondary to gunshots ($p<0.05$) and a lower incidence of death secondary to explosions ($p<0.05$). The 5 decedents without an autopsy were those who were not recovered from a helicopter crash at sea.

Twenty-four (70%) of the 82 cases were selected for detailed review by the panel. Twelve of the 24 cases which were reviewed in-depth were considered to be potentially survivable. During the study period, 12 (15%) of the 82 SOF deaths died from potentially survivable injuries. The 16 mechanisms of injury in these 12 deaths are shown in Table 1. Four (33%) of the potentially survivable casualties were died-of-wounds (DOW), one of which died 56 days after injury at a level V hospital. The other 3 were categorized as having DOW as they were declared dead at a combat support hospital. The remaining 8 (66%) casualties were killed-in-action.

Table 1. Mechanisms of Injury in 82 SOF Deaths (%) and All Combat Injuries from OIF/OEF (Nov 2004)

Mechanism	OIF/OEF n=3789	SOF n=82	NS* n=70	PS† n=12
All explosions	2030 (55)	35‡ (43)	32 (46)	3 (25)
IED§	1201 (32)	16 (20)	14 (21)	2 (17)
RPG**	466 (12)	2 (2)	1 (1)	1(8)
Other Explosions	26 (1)	16 (20)	16 (23)	0
Rockets/Mortar Attack	337 (9)	1 (1)	1 (1)	0
Aircraft crash	33 (1)	19 (23)	19 (27)	0
Motor Vehicle Crash Without IED	579 (15)	4 (5)	3 (4)	1 (8)
Fall	353 (9)	1 (1)	0	1 (8)
Gunshot Wounds	712 (19)	23‡ (28)	16 (23)	7(59)
Total	3707 (100)	82 (100)	70 (85)	12 (15)

*Nonsurvivable
†Potentially survivable
‡p<0.05
§Improvised explosive device
**Rocket propelled grenade

Of those casualties deemed to be nonsurvivable, there were 31 patients with 40 AIS 6 injuries ($p=0.0011$), and 53 patients with 104 AIS 5 injuries. Among the 12 deaths deemed to be potentially survivable, there were only 8 AIS 5 injuries and 18 AIS 4 injuries (Table 2). The distribution of ISS is shown in Figure 1. Eighty-five percent of the fatalities were nonsurvivable (ISS=58+35) while 12 (15%) were potentially survivable (ISS=35+9, $p<0.05$) and provided some basis for potential change in outcomes. Figure 2 shows the distribution of ISS by quartile. Nearly one-half of the nonsurvivable casualties had an ISS of 60 to 75. Using Fischer's exact test, there was a significantly greater percentage of casualties in the potentially survivable group in the ISS 20 to 40 quartile ($p<00.03$).

Table 2. Abbreviated Injury Score (AIS) Distribution*

	Total Scores	PS† n=12	NS‡ n=65
AIS 6	40	0	40§
AIS 5	112	8	104

*n=77 as 5 fatalities due to aircraft crash were not autopsied
†Potentially survivable
‡Nonsurvivable
§p=0.001

The most common etiologic factors in the potentially survivable deaths were noncompressible hemorrhage (n=8) followed by hemorrhage amenable to placement of a tourniquet (n=3), hemorrhage not amenable to placement of a tourniquet yet compressible (n=2), airway (n=1), tension pneumothorax (n=1), and sepsis (n=1) (Figure 3).

Table 3 shows the areas wherein currently available interventions may have resulted in different outcomes for the 12 patients. The reader should remember that the tactical situation for these casualties is largely unknown. Medical care under fire is extremely

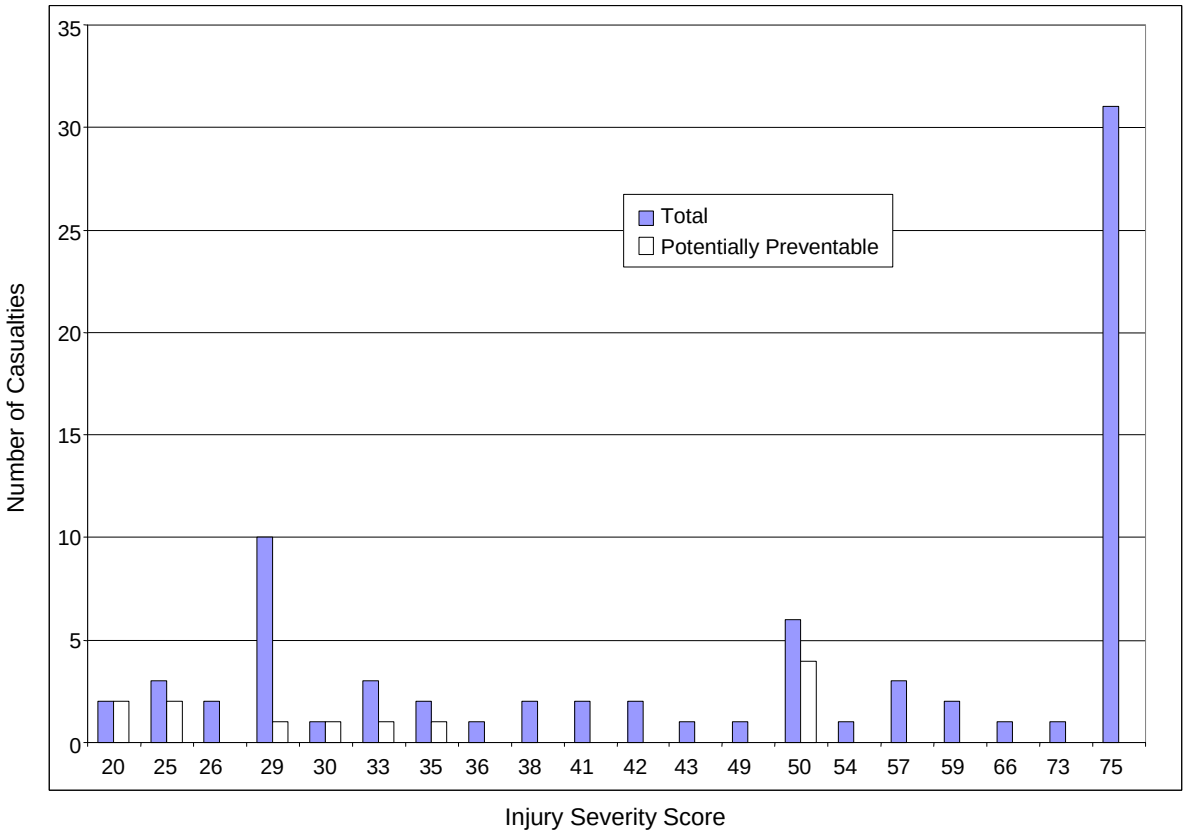

Figure 1. Ranges of Injury Severity Scores for deaths of Special Operations Forces Soldiers in Operations Enduring Freedom and Iraqi Freedom.

hazardous and significantly modifies what can be done for an individual casualty. Additionally, there may exist multiple areas wherein interventions or improvements may have altered the outcome for a single patient. Prehospital opportunities to potentially prevent death included hemorrhage control with tourniquet (n=3) and pressure with hemostatic dressings (n=2), adequate airway (n=1), and needle thoracostomy (n=1). These 8 cases of fatalities from potentially survivable wounds are all covered in the current TCCC guidelines.[8] More expeditious casualty evacuation (CASEVAC) to a facility capable of definitive surgical intervention may have improved patient outcome in 8 casualties. In 3 casualties, improved equipment that is now present in the field, the Combat Application Tourniquet (CAT) (n=1) and use of a hemostatic dressing (n=2), may have altered the final outcome of the casualty. These items, though not available at the beginning of the war, are now used universally.

Table 3. Interventions which may have possibly influenced outcomes for potentially survivable casualties (n=12).

Potential Intervention	Potential Improvement in Outcome
Decreased CASEVAC times	11
Intravenous hemostasis	8
Uniform Application of Current TCCC Training	8
Equipment	3

Table 4 shows that 25% of the potentially survivable casualties sustained injuries in locations that are protected by the current personal protective equipment (PPE). The 3 Soldiers sustained wounds in anatomic locations that are protected by the current body armor used in theatre. Though it is unknown whether or not the armor was worn, the assumption was made, based

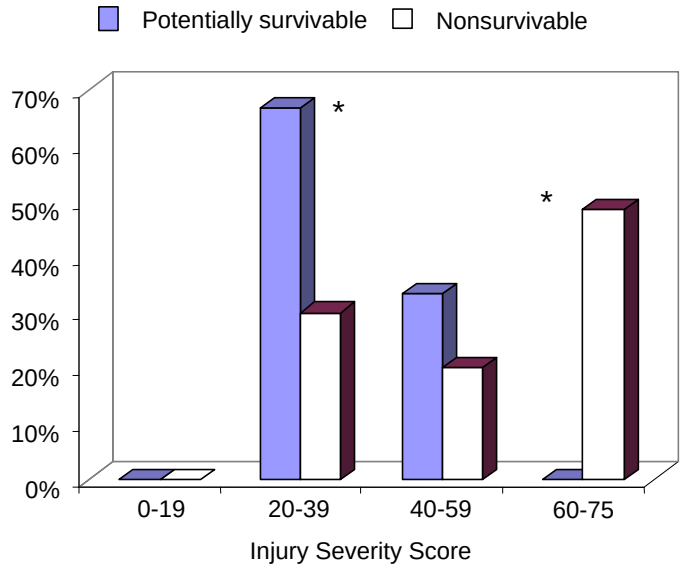

Figure 2. Comparison of Injury Severity Scores of potentially survivable and nonsurvivable casualties.

*Significance p<0.03 Fischer's Exact Test

Table 4. Possible affect of Personal Protective Equipment (PPE) on those fatalities judged to have sustained potentially survivable injuries (n=12).

Injury in area of body covered by PPE?	Total	Percentage
Yes	3	25%
No	9	75%

on the mechanism of injury, that had body armor been worn, the Soldier would have been protected from this particular injury. Of the 82 SOF deaths, there was only one Soldier who sustained a mortal wound to the chest in an area that is not now covered by current PPE.

Eight of the potentially survivable casualties may have benefited from an injectable hemostatic agent or fluid such as recombinant factor VIIa, lyophilized or freeze dried plasma, and oxygen carrying products such as hemoglobin based oxygen carriers. Six major vascular injuries were identified (Table 5). Of these 6 named arteries, 3 of the injuries were amenable to placement of a tourniquet. Hemorrhage was considered to have been a contributing factor in 10 of the 12 potentially survivable casualties.

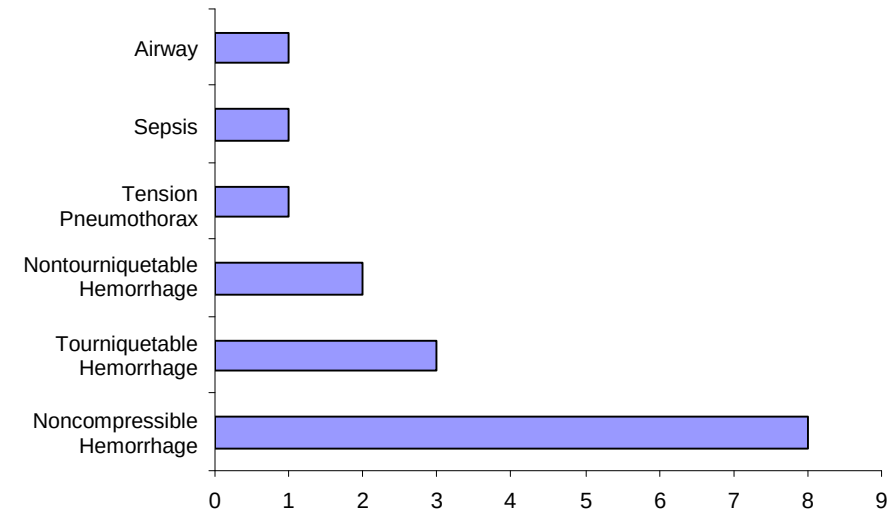

Figure 3. Distribution of the 16 potential causes of death among the 12 potentially survivable casualties.

CASE STUDIES

The following case studies represent the consensus of the reviewing group. It is important again to emphasize that the tactical situation in most cases was completely unknown. The simplest medical care is often impossible in the midst of a firefight, while access to a casualty is often impossible in the terrain frequently encountered in these episodes. As such, the conclusions presented below are based entirely on the objective medical information available from the autopsy and the Joint Theatre Trauma Registry medical records.

Case 1

The individual was wounded by an improvised explosive device (IED). He sustained a penetrating shrapnel injury to the neck with laceration of his right common carotid artery from which he exsanguinated. This death might have been prevented with sustained direct pressure over the bleeding site until surgical repair was accomplished. However, this may be very difficult or not

Table 5. Major Vascular Injuries and Current Methods of Control (n=7)

Vessel Injured	Compressible or Noncompressible	Method of Control
Superficial femoral artery	Compressible	Tourniquet
Popliteal artery (2)	Compressible	Tourniquet
Common femoral artery	Compressible	Direct pressure
Common carotid artery	Compressible	Direct pressure
Common iliac artery	Noncompressible	Surgical repair
Mesenteric artery	Noncompressible	Surgical repair

feasible in certain tactical settings. Use of a hemostatic dressing might have eliminated the necessity for prolonged direct pressure to accomplish hemostasis. There was no evidence that a hemostatic dressing had been placed.

Case 2

The individual sustained a GSW after a helicopter crash. The bullet traversed the retroperitoneum, rectum, and pelvis. No major vascular structures were injured and he lived for almost 5 hours after wounding, indicating a relatively slow rate of bleeding. The injury was determined to have been readily amenable to surgical repair with no injuries to major vascular structures. While there is no specific current intervention which could have been undertaken by the combat medics that would have stopped the intra-abdominal bleeding, clearly a CASEVAC more expeditious than 5 hours would likely have saved him. He might also have benefited if packed red blood cells had been available on the rescue helicopter, as recommended in the Tactical Combat Casualty Care section of the Prehospital Trauma Life Support (PHTLS) Manual.[8(p394)] It is also not know if a hypotensive resuscitation strategy was employed after wounding. This patient illustrates the need for further research into injectable agents which can augment the coagulation mechanism in response to injury. One such area of current research is the use of recombinant factor VIIa. A second therapeutic agent currently under study are hemoglobin based oxygen carriers which function to temporarily restore oxygen delivering capabilities of the circulatory system in the presence of critical anemia. Given the prolonged CASEVAC time, these interventions could possibly have stabilized this casualty, allowing him to reach the surgical unit for definitive treatment.

Case 3

This individual sustained a GSW to the lower jaw that also injured the tongue and upper airway structures. He was reported to have been intubated in the field, but no tube was noted at autopsy. The airway structures at the cricothyroid membrane and below were intact. It's not possible to know from the available data whether the attempted intubation was unsuccessful, or whether the endotracheal tube may have been placed in the esophagus due to the tissue disruption caused by the GSW. However, there were no other potentially fatal injuries noted and the individual was judged to have died from an isolated airway death. There are 2 interventions that could have been life-saving for this individual: 1) proper positioning (the casualty should sit up and lean forward if conscious) to keep blood out of the airway, or 2) immediate cricothyroidotomy if the previous positioning maneuver proved unsuccessful. Both interventions are recommended in TCCC.[8]

Case 4

The casualty was wounded by an RPG explosion and sustained injuries to the right lower extremity at the mid-thigh level and the right forearm at the mid-forearm level. He exsanguinated from the distal superficial femoral artery, despite the placement of 3 field-expedient tourniquets. The treating first responder clearly had the right idea for effective treatment, but lacked an adequate tourniquet and was unable to improvise an effective one in time to control the hemorrhage. There were multiple "cravat and stick" type tourniquets applied to this extremity, yet adequate hemostasis was not achieved. This fatality likely would have been prevented by the CAT tourniquet that is currently being issued to deploying units.[9,10] The death might also have been prevented by improved TCCC training to all members of the unit. The medic in this unit was killed at the start of this engagement and care was rendered by a nonmedical operator. Providing TCCC training to all unit members has been reported to be overwhelmingly successful in a recent paper by Tarpey describing implementation of

TCCC training for all unit members of deploying 3rd Infantry Division units.[11]

Case 5

The casualty sustained a GSW to his upper thigh at an anatomic location judged too proximal for effective use of a tourniquet. His exsanguination could have been prevented by sustained direct pressure on the femoral artery at the level of the inguinal ligament. Certainly sustained, direct pressure would allow time to employ other strategies for hemostasis. Strategies include the use of hemostatic dressings, such as Hemcon® (HemCon Inc, 10575 SW Cascade Avenue, Suite 130, Tigard, Oregon) and employment of hypotensive resuscitation tactics as outlined in TCCC.[8] This case also illustrates another example where the development of intravenous hemostatic interventions may have altered the final outcome.

Case 6

The individual sustained a GSW to both the torso and his right popliteal artery. There is no record or pathologic evidence of tourniquet application. The torso wound was located in an area that would have been covered by body armor had it been worn. This fatality could have been prevented by a combination of wearing body armor, using a tourniquet, and, as this casualty likely exsanguinated from both his extremity and torso wounds, the use of intravenous hemostasis may have proven fruitful in this patient.

Case 7

The casualty sustained a GSW to the lower abdomen following a helicopter crash. The gunshot traversed the patient's mesenteric and left common iliac arteries. He exsanguinated from these 2 vascular injuries, but the time from wounding to death is unknown. This death might have been prevented by a more rapid CASEVAC and the prepositioning of blood products on the aircraft. Again, given the uncertain time from death to wounding, the use of an injectable hemostatic agent to stem ongoing blood loss from a noncompressible source may have allowed sufficient time for evacuation.

Case 8

The casualty sustained a GSW to the mid-back during an ambush. The injury would have been prevented by body armor if it had been worn. The wounds included significant damage to the upper and lower lobes of the right lung, but death might have been prevented by a more expeditious CASEVAC, as the time from wounding to death in this case was 10 hours. Again, a possible intervention that may have impacted this case is the use of recombinant factor VIIa in conjunction with a strategy of hypotensive resuscitation to slow the ongoing bleeding during the evacuation delay.

Case 9

The injury occurred during a fast-rope insertion which resulted in a 25-foot fall to rocky mountainous terrain. The fall resulted in a closed head injury and bleeding from multiple thoracic, intra-abdominal, and retroperitoneal sites. The bleeding sites were felt to have been amenable to surgical repair. A tension pneumothorax was found on postmortem chest x-ray. Whether or not this finding was a post mortem artifact is unknown. The reported time from injury to death for this casualty was 4.5 hours. This individual might have been saved by more rapid CASEVAC, or a needle thoracostomy performed by a medic in the field followed by surgical repair of his injuries. However, it cannot be said with certainty that the individual would not have died from the closed head injury alone. The median lethal dose for a fall is approximately 40 feet.[12] Certainly, this casualty had suffered multiple major injuries. However, the 4.5 hours in delay from injury to death indicates that his injuries were potentially survivable.

Case 10

The casualty sustained GSWs to the chest and abdomen. The wounds resulted in bilateral hemothoracies, a perforated hemidiaphragm, perforated liver, and a perforated right kidney. It is not known whether or not this individual was wearing body armor, but the wounding sites were locations that would not have been covered if body armor had been worn. The time interval from wounding to death is not known. However, these injuries were amenable to surgical repair and this individual might have been saved if he were afforded a more expeditious CASEVAC. Additionally, the use of intravenous hemostatic therapies might have been able to play a role in the care of this patient. This casualty and the previous case probably represent the extreme limit of potentially survivable injuries on the battlefield.

Case 11

The casualty was an occupant in a military vehicle that was impacted by an IED with a subsequent rollover. He had blunt trauma resulting in a fracture of the pelvis, retroperitoneal hemorrhage, and an open fracture of the left femur with a lacerated left popliteal artery. The time to death was less than one hour and it is unknown whether or not a tourniquet was applied above the site of lower extremity bleeding. It is also unknown if the pelvic fracture had been stabilized in any fashion. The use of a sheet or another device to reduce the volume of the pelvis is part of PHTLS training.[8] This injury might have been prevented by seat belts and/or air bags and the death might have been prevented by use of a tourniquet, pelvic stabilization, an intravascular hemostatic agent, and more rapid CASEVAC.

Case 12

The casualty was wounded by an IED with injuries to the head and neck. He was transported to a medical treatment facility where he underwent a prolonged (56-day) hospital course complicated by menigingoencephalitis, pneumonia, and brain abscess. It is not known whether or not this casualty was wearing his helmet or received battlefield antibiotics as recommended by TCCC. However, the injury sustained was in a location covered by the issued helmet. The death might have been prevented by improved treatment of multiple organ failure and sepsis.

DISCUSSION

The US Special Operations Command (USSOCOM) is a unique force in the American military. It was established by Congress in 1987 to create a unified command structure encompassing all Army, Navy, Marine Corps, and Air Force Special Operations units. USSOCOM has a force of less than 51,000 active duty and reserve personnel, with an extraordinary broad range of missions which include direct action, special reconnaissance, foreign internal defense and unconventional warfare, counter and anti-terrorists operations, combat search and rescue, counter-drug, humanitarian assistance, and security assistance. USSOCOM has been designated by the National Command Authority to lead the US Global War on Terrorism.

The medical capabilities and needs of USSOCOM are unique in many respects. Special Operations Forces are often deployed in small units in hostile environments. Thus, SOF combat medics have to be extremely well trained and have the ability to function independently, frequently for days or weeks at a time. Training of an SOF combat medic requires up to 52 weeks of intensive didactic and field work. The baseline medical care doctrine and protocols for TCCC in special operations are generated through the Committee on Tactical Combat Casualty Care, a tri-service, multidisciplinary, military/civilian committee formed in 2002 by the Naval Operational Medicine Institute to ensure contemporary standards of practice. These guidelines are published in the PHTLS manual.[8] The commander of USSOCOM has ordered that every deploying unit in the Special Operations Command be trained in the basic emergency care of combat casualties, utilizing TCCC concepts. This same approach to combat casualty care is rapidly becoming the standard in the conventional forces as well.

Tactical Field Combat Casualty Care is generally broken down into 3 phases:

1. Care Under Fire is care rendered by the medic on the battlefield while under effective hostile fire with an aid bag as the only equipment.
2. Tactical Field Care is treatment provided once the casualty and his unit are no longer under effective hostile fire, with equipment limited to that carried into the field.
3. Combat Casualty Evacuation Care is treatment provided once the casualty has been picked up by aircraft, vehicle, or boat.

The very nature of USSOCOM missions results in the fact that access to and extraction of wounded combatants may be difficult and delayed, thus placing a significant burden on the point of wounding care providers in small units. To prevent an inordinate early death, SOF medics must be highly trained and expertly equipped and supported.

These 82 deaths must be considered in the context of the over 600 casualties who survived their injuries, sustained by Special Operations Forces during the period encompassed by this study. That the vast majority of the casualties from these 2 conflicts survived is a great credit to the courage and

professionalism of the physicians, nurses, medical planners, pilots, aircrew, combat medics, and teammates who cared for our wounded warriors. In the Global War on Terrorism, there is no doubt that the Marine Forward Resuscitative Surgical Suites, Air Force Emergency Medical Deployments System (EMEDS), Army Forward Surgical Team and Mobile Army Surgical Hospital units provide excellent and effective surgical support during the maneuver phase. Likewise, the Army Combat Support Hospitals and the USAF EMEDS level III facilities, strategically located throughout Iraq and Afghanistan, provide state-of-the-art combat casualty care capabilities for the currently more stable insurgency warfare. All of these individuals work under very difficult circumstances and at great risk to themselves to provide life-saving care. As a result of this type of analysis, we now can define where to apply new approaches and strive to make even more improvements in the deployed medical care system. Nothing in this review is meant to detract from their accomplishments. Rather, we mean to learn where improvements in training, equipment, and research are required to save even more lives. This analysis is a focused effort to learn lessons that will help us save casualties in battles yet to come. A follow-on effort will examine the SOF casualties who had wounds that were not fatal, and examine the mechanisms of wounding and the outcomes in that group.

This analysis was limited by incomplete data from the prehospital and hospital setting. The time between wounding and CASEVAC, and the time interval between wounding and arrival at a medical treatment facility (MTF) or death is largely unknown. Also largely unknown were the specifics of care rendered on the scene and during CASEVAC, as well as whether or not body armor and helmet were worn by the casualty. Furthermore, body armor was not usually available for examination in conjunction with the autopsy results. Recording the care rendered and communication of this information are often impractical in the tactical environment. These are areas for potential improvements. Efforts to improve the capture of data on the tactical and prehospital care aspects of SOF combat casualties are underway, both at the US Army Institute of Surgical Research and the US Special Operations Command.

Consistent with the findings from previous conflicts,[4] 85% of the fatalities were not survivable. After analysis, and as evidenced by the distribution of the AIS and ISS scores (Figures 1 and 2), 70 (85%) of the fatalities were judged to have been wounded so severely that survival would have been impossible even with Civilian Level 1 trauma care. Only 12 (15%) of the deaths were categorized as potentially survivable.

A comparison of these patients with published reports[13,14] of civilian trauma care in the United States is a testament to the training, the skills, and the battlefield successes of the Special Forces combat medic. These papers report that 8% to 22% of prehospital deaths are preventable, or potentially preventable. The potentially survivable rate of 15% documented in the fatalities examined by this study falls into this range. Moreover, the casualties reviewed in this study were more severely injured that those reported in the civilian literature. The reported mean ISS of the potentially preventable patients in one study[14] was 25, while our population of potentially survivable deaths had a mean ISS of 35. The overall mean ISS of the reported 88 civilian deaths was 51.6 and our military population was 56. It is a tribute to the Special Operations medic to have a rate of potentially survivable deaths similar to the low end of that reported in the civilian literature, given the severity of injuries treated combined with an austere and hazardous environment. The comparison of the management of civilian trauma patients and the field management of combat casualties is challenging, as there is no easy way to know the tactical situation in which the combat medic is required to operate, nor is there a civilian equivalent to the mechanisms of injury experienced. There are few civilian equivalents by which comparisons can be made.

The use of the ISS as a predictive tool for outcomes in the combat trauma has significant limitations. The ISS is obtained by summing the square value of the three highest AIS scores in up to 3 separate body regions. For example, a Soldier wounded by an IED has an AIS 5 for an abdominal injury, AIS 4 for a chest injury and an AIS 3 for an extremity injury. His ISS would then be 50, representing a severe injury. The limitation here is that the ISS does not account for multiple injuries to the same body region, nor does the ISS consider bilateral injuries. In our example, this same Soldier may have more than one AIS 5 injury in his abdomen, or a concomitant AIS 4 injury in addition to multiple AIS 4 injuries in his chest, or bilateral AIS 4 extremity

injuries. The conventional ISS scoring system does not account for these highly significant injuries. Injuries sustained as a result of combat mechanisms, ie, high velocity GSWs from military ordnance and explosions, tend to have multiple injuries within the same body region. In our population of potentially survivable deaths, there was one patient with 2 AIS 5 scores for his chest, only one was counted in the calculation of his ISS. Four other patients with AIS 5 injuries had concomitant AIS 4 injuries in the same body region. Combat casualties tend to have multiple severe injuries that remain unaccounted for by the conventional ISS scoring system. A new injury severity scoring mechanism, taking into account the differences between combat and civilian injuries, is under development.

A study of 210 combat fatalities from Vietnam published in 2002 reports cases which were independently reviewed by 4 trauma surgeons and assessed to be either definitely preventable, possibly preventable, not salvageable, or cannot determine.[3] The study was done using medical records, there was no tactical information available, and no autopsies were performed. The determination of preventable or nonpreventable was made against the current standard of care, not the standard of care rendered during the Vietnam War. Averages of 5.4% (range 1.0% to 11%) of the 210 cases were determined to be definitely preventable and 34.9% (range 26.2% to 41.9%) possibly preventable. Though the percentage of fatalities with potentially survivable wounds in our study was similar, the results are difficult to compare to this study as the methodology was markedly different. The paper by Blood et al used hospital medical records, and only considered patients who were DOW and not killed-in-action.[3] Therefore it was not an evaluation of care rendered on the battlefield, but rather of care rendered at higher echelons of care.

The topic of improved personal protective equipment has garnered a significant amount of attention during this conflict. Analysis of these data suggests that PPE is saving lives. Only one Soldier of 82 sustained a potentially survivable injury to the thorax that may have been prevented by improved PPE coverage. There were 3 potentially survivable deaths whose injuries might have been prevented had PPE been worn. Two sustained GSWs to the thorax and the third suffered a fragmentation injury to the head. The AIS data presented suggests that many of these casualties sustained multiple severe injuries in multiple anatomic regions that any body armor acceptable for use in the tactical environment could not have prevented. Inadequate anatomic coverage of the currently fielded SOF body armor was not documented in this study. In addition, no cases were documented where body armor failed to stop the high velocity munitions commonly encountered in current military operations, bearing in mind the previously noted lack of reliable information about whether or not body armor was worn by the casualties.

There was a significant difference in the mechanism of injury by which the SOF deaths occurred compared to conventional forces. The SOF Soldiers were more likely to die from gunshot wounds than from an explosive mechanism, 28% versus 19% respectively ($p<0.05$), using a logit case control odds ratio, 95% confidence interval of 1.42 to 4.03. In contrast, the conventional Soldier was more likely to die as the result of an explosion, 55% versus 43% respectively ($p<0.05$). Historically, in the Vietnam conflict, 51% to 52% of all deaths at an MTF were the result of gunshot wounds, followed by explosions at 44% to 48%.[3,4]

There are multiple levels at which improvements in management strategies can theoretically improve outcomes:

- TCCC training for nonmedical combatants; medical training and equipment
- Air evacuation and close air support resources
- Operational medical planning
- Location of receiving MTFs
- Improvements in surgical techniques and technology
- Improvements in postoperative care
- New medical interventions stemming from evidence-based research

No new training requirements were identified. TCCC training was applicable to the nonsurgical deaths while standard surgical techniques and equipment apply to the remainder. Mandatory predeployment trauma training and uniform application of these principles are required. The analysis of the potentially survivable deaths serves to emphasize many points in current SOF TCCC training:

- The need to use a tourniquet for extremity wounds with life-threatening bleeding to gain initial control of hemorrhage
- The need to use sustained direct pressure when confronted with severe external bleeding at an anatomic location where a tourniquet cannot be applied
- The need to use proper casualty positioning and cricothyroidotomy instead of intubation for maxillofacial trauma associated with airway trauma
- The need to decompress a tension pneumothorax with a 5-inch needle

The very small number of fatal outcomes associated with these issues suggests that, in most cases, these types of injuries were treated appropriately by SOF combat medics. One possible reason for these events (except for the failed intubation) is that there may not have been a medic to provide treatment. In most cases, it is not stated in any available record whether the wounds were initially treated by a combat medic or a nonmedical SOF operator. In some instances, there may not be a medic on the mission at the time casualties occur. At other times, as occurred in one of the deaths described above, the unit medic may be killed or incapacitated and unable to provide care for other wounded unit members. The TCCC Transition Initiative currently being conducted by USSOCOM is designed to provide all SOF operators (medical and nonmedical) in deploying units with the basic medical skills.[15,16]

Three cases were identified where the casualty had hemorrhaged from a site that was amenable to placement of a tourniquet. Two of these three had no tourniquet placed and one was a tourniquet failure. These 3 isolated extremity deaths have been addressed by a major Department of Defense initiative to field the new CAT tourniquet.[10,17] This device was tested by USSOCOM operators and trauma surgeons and found to be superior in function and feasibility to the traditional cravat and stick. Using the traditional cravat and stick method, while effective, is time consuming, difficult to secure in place and requires prior planning to assure availability of a stick.

All of the potentially survivable fatalities might have benefited from more expeditious CASEVAC to an MTF, with the possible exception of Case 12. However, unless the exact time from wounding to death is known for a specific casualty (which it rarely was in this case series), it is difficult to say what impact the actual CASEVAC time actually had. Attempts to minimize CASEVAC time are limited by aircraft resource constraints in operational planning, ground fire preventing CASEVAC aircraft from landing, and lack of readily available MTFs in far-forward SOF operations. The ability of reduced CASEVAC time to prevent fatalities is clearly demonstrated by the 2 potentially survivable casualties who lived at least 5 to 10 hours before evacuation was accomplished. With the dispersed nature of SOF operations, it is unlikely that surgical facilities and CASEVAC capability will ever be able to provide the rapid evacuation capability required to save these casualties. Interventions placed into the hands of medics will be required, thus the emphasis on intravenous hemostasis for the noncompressible bleeding sites, which contributed to death in 7 of the 12 potentially survivable deaths.

Current operations in Iraq are heavily focused on urban vehicle-based missions whereby the evacuation time from point of wounding to nearby MTFs may be 30 minutes or less, a very fast evacuation time for military casualties. In contrast, Afghanistan operations are usually conducted in remote areas far from medical assets. CASEVACs in OEF are still usually accomplished by rotary-wing aircraft and may have very significant delays due to both difficult flying conditions in the rugged mountainous terrain of the Hindu Kush and the remoteness of operations from surgically capable MTFs.

Great difficulty may be encountered in evacuating casualties from high-threat environments. Hostile rocket-propelled grenade fire has downed US helicopters engaged in CASEVAC operations in the past. Suppression of hostile fire is a critical element in situations where intense ground fire from hostile forces could impede or prevent rotary-wing CASEVAC. Expeditious evacuation might be more readily available if there were an improved close air support capability for daytime SOF CASEVAC missions. Technology to harden rotary wing platforms against RPG fire would also be useful. Operational planning that ensures availability of CASEVAC aircraft is to no avail if the aircraft cannot safely pick up the casualty.

Another factor that impacts time to surgical care is the proximity of the nearest surgical facility. Since SOF units often operate in areas remote from forward support bases, CASEVAC time can be shortened by prepositioning a Forward Surgical Team (FST) with SOF units when they will be conducting remote operations that can be expected to generate significant numbers of casualties. SOF units operating under these circumstances must have rapid access to FSTs. If the deployment of forces is such that conventional FSTs cannot respond in time to meet the operational tempo, then improved access is available by requesting one of the FSTs now attached to the Air Force Special Operations Command. While this surgical support is logical, the very casualties that will require time sensitive resuscitative surgical support are extremely difficult for an FST to adequately manage, because of the power and equipment requirements for rewarming hypothermic, hypotensive, and acidotic patients, and the large amount of blood and blood products they require. Further confusing the medical planning is the pervasive concept of the "golden hour" which has very little supporting data. Most authorities suggest that 90 to 120 minutes is more likely an evidenced-based planning factor.[18,19] The desire for a lightweight, mobile surgical team that is able to optimally support the deranged physiology of the most critically injured casualties is a conundrum yet to be completely resolved.

The medical research requirement is driven by the 8 casualties that died from noncompressible hemorrhage. These deaths mandate a focus on injectable hemostasis at all levels of care, especially by medics. Currently the paradigm of Damage Control Resuscitation holds the most immediate promise in this area.[20] This concept involves the utilization of prohemostatic fluids in conjunction with pharmacologic adjuncts such as recombinant factor VIIa and hypotensive resuscitation to palliate the hemorrhaging casualty until arrival at a facility where definitive care can be provided. Although human efficacy when using rFVIIa alone in the prehospital environment is absent, rFVIIa appears to be a promising hemostatic adjunct. Fortunately, safety and efficacy in trauma patients has recently been established, and the prospect of prehospital noncompressible hemostasis is tantalizing.[21,22] Efforts are underway to study this application. Perhaps combining rFVIIa with other clotting factor concentrates will provide both the substrate and the thrombin burst required to accelerate clotting.[23-25] It is possible that, by accelerating/strengthening the endogenous clot, blood loss will decrease; the casualty will be stabilized allowing arrival at the surgical facility in an improved physiologic condition, where surgical intervention may improve outcomes. Damage control resuscitation may allow the SOF casualty to tolerate the longer CASEVAC times we have seen in this population.

A second potential intravenous intervention that is currently in ongoing phase III trials in the United States is the evaluation of the prehospital administration of hemoglobin-based oxygen carriers (HBOC). This HBOC replaces the oxygen carrying capacity of shed blood allowing for delivery of oxygen to vital organs during critical anemia.[26] If current trials support this indication, this intervention would allow a SOF medic to maintain oxygen delivery while awaiting evacuation.

At least 7 of the 12 patients may have benefited from more rapid CASEVAC times—some lived upwards of 10 hours after injury. It is during this time that damage control resuscitation can be employed, especially in a far-forward environment where CASEVAC is not always readily available. Additionally, this strategy could potentially decrease the amount of blood loss in a casualty regardless of the CASEVAC time. The application of damage control resuscitation is particularly salient to the SOF casualty, where the tactical situation may prohibit expeditious CASEVAC. Damage control resuscitation would allow the SOF medic to temporarily stabilize a hemorrhaging patient while CASEVAC is en route.

History is replete with numerous examples that go back a thousand years in which combat casualty care providers use every means available to provide emergency care to combat casualties, and effectively match available resources with the needs of those injured. History also documents that improvement in combat casualty care stems from the unfortunate repetitive experience of the war injured. The findings provided by this study that will enable the military to continue to improve battlefield trauma care are:

1. Eighty-five percent of SOF fatalities in the GWOT resulted from injuries that were judged to be nonsurvivable.

2. Consistent application of the currently taught TCCC guidelines might have improved outcomes for 8 of the 12 fatalities with potentially survivable injuries.
3. Faster CASEVAC times might have improved outcomes for 11 of the 12 fatalities with potentially survivable injuries.
4. The most important biomedical research requirement identified in the study is Damage Control Resuscitation which incorporates the use of prohemostatic adjuncts, such as recombinant factor VIIa, lyophilized plasma, and thawed plasma with hypotensive resuscitation and HBOCs. At present, this represents the most promising modality to improve outcomes in the 8 fatalities with noncompressible hemorrhage.
5. When worn, currently fielded body armor provided adequate anatomic coverage for the injuries discovered in this study.
6. No cases where body armor failed to stop high velocity munitions were documented in this study.
7. Improved suppression of hostile ground fire is critical to assuring CASEVAC availability in some tactical situations.
8. Improved methods to capture records of wounds sustained and care rendered on the battlefield will greatly improve future efforts to update battlefield guidelines.

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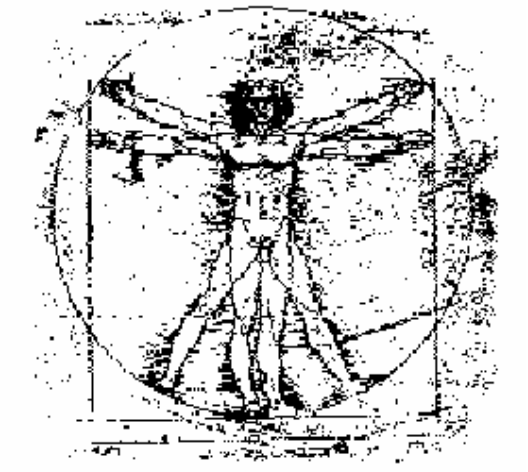

The Process of Care of Battle Casualties: Orthopaedics and Rehabilitation at the Walter Reed Army Medical Center

COL William C. Doukas, MC, USA

INTRODUCTION

Walter Reed Army Medical Center (WRAMC), an echelon V facility, has been a primary hub in the United States for the reception of Army battle casualties from Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF). The care of Soldiers from injury to final disposition has been a joint service and specialty effort. This article is comprised of four sections detailing experiences from the Orthopaedic Surgery, Physical Therapy, Physical Medicine and Rehabilitation, and Occupational Therapy Services. Together, the sections depict the process of care that was developed to affect the timely and effective management of these casualties, with emphasis on a predetermined, multidisciplinary approach to patients and recommendations to facilitate this process at WRAMC and other medical centers. In the time since the article was written, the structure of the process has been modified and integrated into the care of a continuous flow of large numbers of Soldiers with contaminated, multiextremity injuries that frequently require multiple surgical procedures and complex medical management, followed by extensive rehabilitation and strong social support.

PART 1
THE ORTHOPAEDIC SURGERY SERVICE

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BEFORE CASUALTY ARRIVAL

The Orthopaedic Surgery Service is involved with specific battle casualties via electronic mail and ongoing communication with care providers at overseas regional medical facilities. The initial communication is paramount in managing resources and operating room schedules within the Orthopaedic Surgery Service. The information—in the face of the continuous influx of patients requiring multiple surgical procedures, extensive rehabilitation, many with complex social situations—allows orthopaedic surgeons to direct the management of numerous patients as well as the census on the wards and outpatient facilities. This includes the decrease of elective orthopaedic surgery procedures and clinic sizes, as well as the diversion of orthopaedic patients who are not TRICARE Prime subscribers.

Transfer of the bulk of battle casualties to the continental United States (CONUS) is completed by the USAF Air Evacuation System (AEROVAC). The system routinely provides a manifest of casualties with the definitive inbound manifest, which is often finalized after AEROVAC departure. This manifest and estimated time of arrival was communicated to the AEROVAC office at WRAMC, and was then subsequently made available to a variety of staff, including the orthopaedic surgical resident on-call. It was a responsibility of the orthopaedic resident to check with the AEROVAC office daily to acquire

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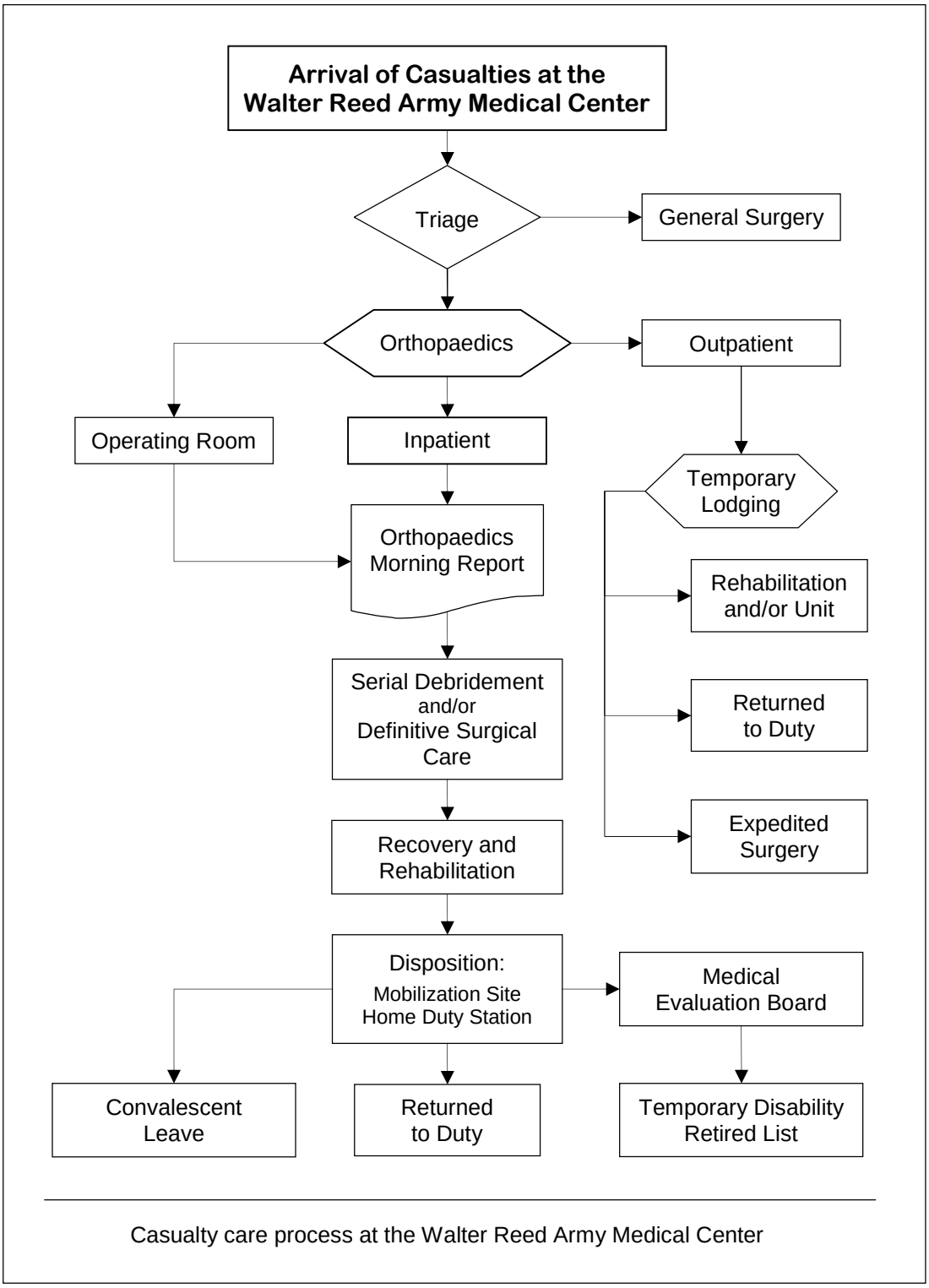

Casualty care process at the Walter Reed Army Medical Center

flight manifests. The resident then used prior email information and the manifest to estimate the number and acuity of patients who would require triage upon arrival. The review process also allowed the resident to anticipate the number of admissions, the need for consultation with other medical/surgical specialties, and plan for potentially urgent surgical cases. The information was conveyed to the Charge Nurse who further coordinated with other health care providers and administrators for the anticipated arrivals. The

majority of patients arrived during off-hours, usually in the middle of the night. It was, therefore, imperative to preplan to ensure appropriate personnel, equipment, and bed space were available. It was also the responsibility of the orthopaedic resident, with the assistance of the Patient Administration Division, to ensure that the demographics of arriving orthopaedic casualties had been appropriately entered into the WRAMC computer system. This allowed casualties to be formally admitted to the hospital and orders to be written immediately upon their arrival, to include pharmaceuticals (primarily analgesics), radiology, laboratory, nutritional services (diet), etc.

TRIAGE

The on-call orthopaedic surgery resident was notified when the AEROVAC mission arrived. WRAMC nursing personnel escorted all patients in need of evaluation to the orthopaedic cast and treatment room. This was established as the center for triage because of its large open size that could accommodate both high volumes of patients as well as the required number of health care providers. The orthopaedic cast room is equipped with multiple beds with an attached radiology suite. Using the information received prior to their arrival, the most seriously injured patients were escorted to the cast room for evaluation first, and then those with less severe injuries were placed in other exam rooms throughout the adjacent orthopaedic clinic. However, all patients entered through the cast room for triage, which allowed an orthopaedic surgeon or general surgeon to initially examine and evaluate the patient prior to transport, and facilitate placement in a less acute clinic exam room. A military medical technician or nurse was assigned to each patient and escorted him or her through the entire triage process, while also initiating appropriate paperwork. Patients were than evaluated in a routine triage fashion, including primary and secondary surveys, with attempts to evaluate the most seriously injured first.

The specialty of the assigned primary triage resident was based on the injury complex as determined by the manifest and listed injuries, with either a general surgery resident or an orthopaedic surgery resident in the lead. The remainder of the triage team consisted of an anesthesiology resident, pharmacist, radiology technician, charge nurse, critical care nurse, as well as nurses aides and technicians. Pending primary and secondary survey, including radiographic imaging and wound assessment (with the assistance of the Anesthesia Service), patient dispositions were determined. This was facilitated by communication between members of the Orthopaedic Surgery Service, General Surgery Service, and the Anesthesia Service. Patients requiring surgery were taken directly to the operating room for irrigation, debridement, wound exploration and, less frequently, definitive treatment. If patients were not taken to the operating room, they were either directly admitted to the hospital or referred to one of WRAMC's outpatient facilities with instructions to return for appropriate outpatient management and definitive disposition.

INPATIENTS

The Orthopaedic Surgery Service admitted all patients that needed further extremity reconstruction, wound management, and/or rehabilitation. The General Surgery Service admitted all patients with chest, abdominal, or uncomplicated extremity wounds. The two Services worked together to manage the volume of casualties with frequent consults to each other as well as other specialties throughout the hospital, often involving the Vascular Surgery, Neurosurgery, Plastic Surgery, and Physical Medicine Services. A standard set of physician orders was established by the Orthopaedic Service to maintain continuity and quality of care of the orthopaedic inpatient. This included deep venous thrombosis and twice daily gastrointestinal prophylaxis of unfractionated heparin and ranitidine, continuation of all previously prescribed antibiotics (pending species identification), and aggressive pain management. All casualties received diet orders that included nutritional shakes, a protocol based on early lab values demonstrating that the majority of casualties were malnourished in their healing stages. The orthopaedic resident was also responsible for identification of those arriving patients who needed malarial prophylaxis and initiation of appropriate treatment

The following morning, all patients were presented by the orthopaedic on-call resident at the daily Morning Report, which routinely consists of a review of all preoperative and immediate postoperative patients, as well as all patients evaluated on-call. All attending orthopaedic surgeons and in-house orthopaedic residents attend this meeting. The battle casualties were presented in the usual fashion, which stimulated

further discussion among attendees, and a preliminary care plan was established. The use of digital photography obtained at time of triage by the orthopedic resident was important in accurately presenting the complex, contaminated wounds sustained by many of the patients. Information on incoming casualties was also shared at this forum and tentative plans were made accordingly. The chief resident would then review and update posted 2-week futures of all battle casualties needing operative treatment. This was imperative to effectively manage all resources and ensure that patients needing serial irrigations and debridements were adequately managed. This also allowed the resident teams to complete and submit the appropriate operative request slips and purchase orders ahead of time, as well as contacting equipment representatives and coordinating with consulting services in order to prepare the battle casualty for surgery.

Following Morning Report, the junior orthopaedic resident or intern would submit 9 routine consults (audiology, discharge planning, nutrition care, occupational therapy, pastoral, psychiatry, physical medicine and rehabilitation, physical therapy, and social work) throughout the hospital on every OIF/ OEF patient. For all open wounds, the Infectious Disease Service was consulted and routine operative tissue cultures obtained. It was the responsibility of the orthopaedic resident to coordinate all consults and ensure that the orthopaedic team had addressed the recommendations.

The orthopaedic management of inpatients was based on routine trauma management, yet the type of trauma differed from the routine civilian blunt trauma. The average battle casualty consisted of a blast injury involving multiple extremities, with multiple soft tissue and bony injuries. The wounds were often contaminated, requiring serial irrigation and debridement and aggressive wound management with delayed primary closure rather than skin, free, or local flaps and grafts. The orthopaedic treatments consisted of amputations, revision amputations, flaps, a large number of wound vacuum-assisted closure devices, antibiotic-impregnated polymethylmethacrylate beads, and a variety of fracture stabilization procedures for limb salvage.

The orthopaedic resident made a continuing effort in the disposition of patients to other medical treatment facilities (MTFs). The disposition of patients to other military MTFs was difficult because of the extensive number of casualties experienced in the face of the ongoing war, which limited the number of CONUS AEROVAC flights. The disposition of Active Army Soldiers was routine pending travel arrangements to their home duty station. The disposition of the Army National Guard or Army Reserve Soldiers was challenging due to the administrative complexity introduced because the home of record usually differed from the mobilization site, and the associated lack of surrounding military medical facilities in a given region. Every effort was made to return the Soldier to their mobilization site, assuming appropriate follow-up and therapy could be obtained. Medical evaluation boards, if required, were completed at time of discharge or at time of optimal functional improvement.

THE OUTPATIENT CASUALTY

An orthopaedic nurse case manager expedited the management of outpatient battle and nonbattle casualties. This nurse case manager coordinated all appointments and expedited surgical scheduling with an attempt to schedule operative within a 2-week time frame. All patients that were triaged to an outpatient setting were given follow-up dates with appropriate attending physicians. If a patient was seen at triage and no orthopaedic issues were identified, he or she was then referred to the appropriate Service for medical care. Outpatient surgical cases received priority over all elective cases not originating in one of the combat theaters in an attempt to reduce the large volume of outpatients.

CONCLUSIONS

The evolution of the process of care of battle casualties is an ongoing process. It is imperative to initially establish and implement a hospital-wide plan addressing logistics and process of care. The most important issue, however, remains open, ongoing bidirectional communication between the transferring and receiving facilities, as well as between departments, services, and providers. We recommend that appropriate legal personnel within the institution establish a working protocol that allows transfer of patient information while remaining compliant with current Health Insurance Portability and Accountability Act regulations. We also suggest a unification of the digital radiographic systems and/or establishment of communication links between overseas systems to eliminate duplication of effort. This will be cost-effective, safer for the patient, and

ultimately improve efficiency. Finally, we suggest implementing a plan that automatically incorporates all of the routine consults that are required in the care of the battle casualty. The myriad of administrative tasks (eg, discharge planning, HIV testing, TB testing, malaria prophylaxis, family travel, etc) cannot be relegated as a responsibility of the primary surgical team in the face of large numbers of battlefield polytrauma patients that are arriving from combat operations. The disposition of Soldiers from the receiving institution to their home units or regions is still not seamless. WRAMC continues to refine this protocol.

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PART 2
PHYSICAL THERAPY

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As part of a patient-centered team, physical therapists, physical therapy assistants, and physical therapy technicians are dedicated to providing the best possible care to wounded Soldiers, Sailors, Marines, and Airmen returning from Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF) for treatment and rehabilitation. Therapists work closely with other health care providers such as orthopaedists, neurologists, physiatrists, occupational therapists, speech/language therapists, prosthetists, social workers, nursing staff, and psychologists to return the Soldiers to the highest possible level of activity.

OEF/OIF patients are referred to inpatient or outpatient physical therapy primarily from physiatrists and orthopaedists. During the first month of combat operations, the physical therapist on-call was present at the triage center with orthopaedic, general, and vascular surgeons to identify patients with physical therapy needs, assist with dressing changes, and communicate directly with the surgeons about weight-bearing status, restrictions, and precautions. This allowed thorough consultations, enhanced communication, and inpatient physical therapy staff planning. However, due to the number and frequency of patients from overseas and the hours of arrival, it was decided that on-call physicians would triage and make recommendations and referrals within 24 hours.

INPATIENT PHYSICAL THERAPY

Inpatient consults are typically received within 24 hours of admission or when the patient is stable enough to receive physical therapy. Physical therapists provide evaluations and treatments for these OEF/OIF patients on any of the wards, to include the intensive care units. Most injuries incurred by these patients are caused by landmines, improvised explosive devices, rocket propelled grenades, gunshot wounds, and motor vehicle accidents. Examples of common conditions evaluated and treated by the physical therapy staff include multiple trauma, soft tissue injuries, burns, skin grafts and flaps, fractures, amputations, traumatic brain injuries, hemiplegia, spinal cord injury, and vestibular dysfunction. Unfortunately, many patients do not sustain only a single injured limb, but rather suffer multiple injuries and conditions. For example, challenging patients include those who undergo double or triple amputations, are blinded, and suffer traumatic brain injury. Physical therapy treatments include bed mobility, transfers, gait training, don and doffing of prosthesis, mat exercises, residual limb desensitization, strengthening, stretching and range of motion, conditioning, aquatic therapy, balance training, neuro rehabilitation, and patient and family education. Inpatients are treated twice daily where appropriate on weekdays and once a day on weekends. There is a pool of contract weekend physical therapists, and physical therapy assistants and technicians. Two of each are scheduled to work every Saturday and Sunday. If there is a need for more than 4 staff members on the weekends, the military on-call physical therapist and/or technician will assist. In order to provide continuity of care for our amputees throughout the entire week, rotating schedules were created for our full-time amputee therapists.

Inpatient physical therapists work closely with social workers and nurse case managers to coordinate further care, to include evaluating rehabilitation and equipment needs. Occasionally an OEF/OIF patient must go to a specialized Veteran Affairs rehabilitation hospital for severe traumatic brain or spinal cord injury rehabilitation. Other times they are discharged and stay in the local guesthouse awaiting further surgery and/or wound checks. Inpatient physical therapists also help coordinate outpatient physical therapy, whether it is at Walter Reed Army Medical Center (WRAMC), at the patients' mobilization site, or home. Sometimes patients go home on convalescent leave, then return for further work-up and/or rehabilitation.

OUTPATIENT PHYSICAL THERAPY

Outpatient physical therapy is provided within 72 hours (typically less) of receiving a consult from health care providers, such as physiatrists or orthopaedists. Three mornings each week are dedicated to OEF/OIF patients, as well as any other Active Army patients. After the patients are evaluated, physical therapists determine their rehabilitation needs and may refer them to other specialty clinics such as neurology or orthopaedics. A detailed treatment plan for physical therapy treatment at WRAMC is written for patients who are staying for any other health reasons, or patients are referred to other military or civilian physical therapy clinics, depending on their status. There is a dedicated nurse case manager for the OEF/OIF patients to help coordinate their medical needs at their mobilization sites, or at home should they go on convalescent leave.

PROBLEMS, SOLUTIONS, LESSONS LEARNED

The number of multiple traumas, blast injuries, gunshot wounds, amputations, and burns incurred by OEF/OIF patients are numerous. Their requirements are not the typical ankle pain or low back strain patients we would normally evaluate and treat in outpatient physical therapy. OEF/OIF patients have a much higher acuity and require many more resources, ie, increased staff and time. Physical therapy of double and triple amputees, or blind amputees with multiple limbs involved is not uncommon, and many injured patients have traumatic brain injury and/or open wounds and fractures. The patient profiles have caused a major shift in focus. The increase in OEF/OIF patients made it necessary for the Physical Therapy Service to go to a prime-only status, which reduced our outpatient visits by approximately 45%. This resulted in decrements in physical therapy specialty services such as vestibular rehabilitation, total joint evaluation and treatments, and chronic obstructive pulmonary disease exercise classes.

Solution: Army Reserve specialists should be called up early and dedicated to services, such as physical therapy, to help ease the burden on the regular staff during this time of increased casualties. WRAMC provided funding to hire 3 additional contract physical therapists and a single physical therapist assistant to continue providing quality care for all. The amputee section staff was increased from 1 to 3 physical therapists, in addition to the existing single physical therapist assistant. Another solution was to send patients over 65 years old, such as many of the diabetic amputees, to civilian facilities where they could use their Medicare benefits. Additionally, civilian security personnel were hired for the WRAMC gates, freeing Soldiers to concentrate on the provision of patient care.

There was a greater need for space in both the 3rd and 5th floor clinics at WRAMC due to the greater need for patient equipment, such as inpatient beds, geri chairs, wheelchairs, and prosthetics. Additionally, space was needed to provide safe functional training, especially for our young traumatic amputee population. Functional training includes balance training, functional drills, hopping, running, climbing, and ambulating on uneven terrain. These patients could be progressed to high levels of function, to include athletic competition and military duties. However, adequate space would allow better rehabilitation services.

Solution: A temporary solution is to work with some of the patients outside (when the weather cooperates) or at the physical fitness center on the WRAMC campus. A long-term solution is to build a dedicated clinic space for our amputee population. In 2002, Congress provided funding to establish an amputee care program for these young, healthy, highly functional Active Army Soldiers who sustain traumatic amputations. Dedicated clinic space that can be shared by all the team members involved in amputee care is planned for construction.

There has been some difficulty tracking OEF/OIF outpatients. No particular caseworker was accountable for patients who stay at the local guest house. There was no one to contact if they did not appear for scheduled physical therapy treatments. There should be current and specific guidance on the management of OEF/OIF patients, including the length of stay, location of further evaluations and/or surgeries, follow-on outpatient physical therapy, and eligibility issues.

Solution: A nurse case manager has been coordinating care for the OEF/OIF patients and she is available for answers to these questions. Additionally, a nurse case manager was hired specifically for the amputee patient management.

We believe that the media and visiting VIPs have a positive effect on the casualties. It is very important to the patients. However, it is occasionally excessive and may interfere with getting patients to the physical therapy clinic for treatment.

Solution: We should certainly allow VIPs and the media to visit, but there must be close coordination with the public affairs office and our service. Another suggestion is to limit VIP visits to evening visiting hours (or at least after 1500).

Some military patients are being brought back from Iraq because of preexisting conditions (such as hammer toes, chronic knee, or chronic back pain). Our resources are used to evaluate and treat these patients.

Solution: Health care professionals at medical evaluation sites should closely screen those who are being called to active duty to ensure they meet the physical requirements and can perform their duties before they are deployed.

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PART 3
PHYSICAL MEDICINE AND REHABILITATION

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INTRODUCTION

The Physical Medicine and Rehabilitation Service (PM&R) plays a critical role in the assessment, management, and disposition of the injured combatant. This role was well demonstrated during Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF). Placement of the PM&R Service within the same department as orthopaedics, physical therapy, and occupational therapy greatly enhances the communication and flexibility to provide optimal medical and rehabilitative care for those injured combatants with musculoskeletal injuries.

INPATIENT CONSULTS

All combat casualties who are admitted to Walter Reed Army Medical Center (WRAMC) receive several automatic referrals, including an evaluation from the PM&R Service. PM&R consultation to the primary admitting service helps focus each patient's rehabilitation plan at the earliest possible moment. PM&R consultations also help to identify other comorbidities such as peripheral neuropathies, fractures, and mild traumatic brain injuries that might not have yet been identified during the initial acute phase of inpatient treatment. In addition to providing

comprehensive rehabilitative care plans, it is customary for PM&R consultations to provide recommendations for pain management, bowel and bladder management, strategies for avoiding complications of immobility such as deep venous thrombosis, skin breakdown, or contracture formation. Also, PM&R consultations develop the coordination plans with social work services and allied health professionals to ensure appropriate disposition, which often includes transition to an inpatient rehabilitation service.

The primary goal of the PM&R consultation is to establish the framework for the holistic management of the patient and to ensure that all strategies for restoring optimal function are being considered.

INPATIENT PM&R SERVICES (INPATIENT REHABILITATION)

While the average daily census of the WRAMC inpatient rehabilitation unit is customarily between 8 to 12 beds, the number of inpatient PM&R beds can be increased given command approval, space availability, and appropriate staffing. During wartime, priority for admissions is appropriately given to injured active duty service members who require inpatient rehabilitation. Guidelines for admission are similar to those criteria used by civilian inpatient rehabilitation units and include:

1. The patient has a condition that is amenable to inpatient rehabilitation interventions.
2. The patient is motivated and is able to participate in a minimum of 3 hours of therapy (physical, occupational, speech, psychological, or recreational) per day.
3. The patient has the capacity to learn and show carryover from day to day in order to meet identified functional goals.

The inpatient rehabilitation unit at WRAMC has special challenges when caring for combat casualties. Injured service members who need inpatient rehabilitation often present with complex injuries and multiple comorbidities, which require creative solutions to progress in rehabilitation. For example, a right transtibial amputation may be ready for prosthetics training and ambulation, however non-weight-bearing fractures on the contralateral limb may prohibit this from occurring. Other examples illustrating the complex challenges injured combatant pose for the rehabilitation specialists include blind double amputees, spinal cord injuries with concomitant peripheral nerve injuries, or multitrauma victims also suffering from post-traumatic stress disorder. Because of the specialized facility requirement and need for protracted rehabilitation in the treatment of high spinal cord injury or severely impaired head injury patients, the WRAMC inpatient rehabilitation unit will generally initiate immediate transfer of these patients to a more specialized facility closest to the patient's home of record.

The Inpatient Rehabilitation Unit is collocated with the inpatient Orthopaedic Service. Given the large number of Soldiers with extremity injuries, such collocation facilitates the transfers of patients within the hospital, while improving communication between physicians, nurses, therapists, and other healthcare professionals. The inpatient rehabilitation unit has many dedicated and caring military and civilian nurses trained in medical-surgical nursing, however, cross-training in rehabilitation is also required. Therefore, an ongoing educational process must exist to ensure the highest level of care. Critical to the functioning of the inpatient rehabilitation unit is the active participation of a multidisciplinary team. The corps members of this team include: PM&R, physical and occupational therapy, social work, nursing, and psychiatry.

Having the rehabilitation unit located within the echelon V facility ensures the highest quality of care for these complex patients. First, it ensures continuity of care as these patients are transferred to the rehabilitation unit from multiple different medical specialties (orthopaedics, vascular surgery, general surgery, neurosurgery, internal medicine, etc). Second, if during the rehabilitation phase of recovery a patient develops a medical or surgical complication, immediate multispecialty evaluation and comanagement is available. It is the PM&R specialist's responsibility to serve as the inpatient's primary care physician, facilitating communication between specialties, providing attention to detail in monitoring daily progress, and ensuring the execution of the optimal treatment plan.

The inpatient rehabilitation team must have a close working relationship with the Department of Veteran's

Affairs (VA) in order to expedite the transfer of patients to these facilities when warranted. In addition, the PM&R specialist must have an extensive working knowledge of the military disability system, to include training in writing medical evaluation boards, counseling patients on the physical evaluation board process, and writing physical profiles. Most patients admitted to the inpatient rehabilitation unit require complex disposition decisions and extensive administrative processing. It is the PM&R specialist that must ensure all necessary requirements are completed to ensure that optimal long-term care is provided to the patient, whether the patient is returned to duty or transitioned to a VA facility.

CARING FOR THE AMPUTEE

Experience gained during OEF and OIF has further highlighted the special and complex needs of combat amputees. These patients present unique challenges because of the nature of their wounds as well as the extent of their comorbidities. Complex decisions as to the need and optimal length of residual limb revisions, wound management, pain management, timing for prosthetic fitting and weight bearing, types of therapy, appropriate prosthetic components, etc, require a multidisciplinary team approach. To help facilitate this approach and achieve optimal care for these patients, it is best to create an independent amputee service. At WRAMC this service falls within the Department of Orthopedics and Rehabilitation, with PM&R serving as the supervising attending physician. The amputee service is designed to be similar to the Inpatient Rehabilitation Service, with the addition of orthopaedists and certified prosthetists. The process of echelon V care of the combat amputee in presented in the figure.

ELECTRODIAGNOSTIC EVALUATIONS

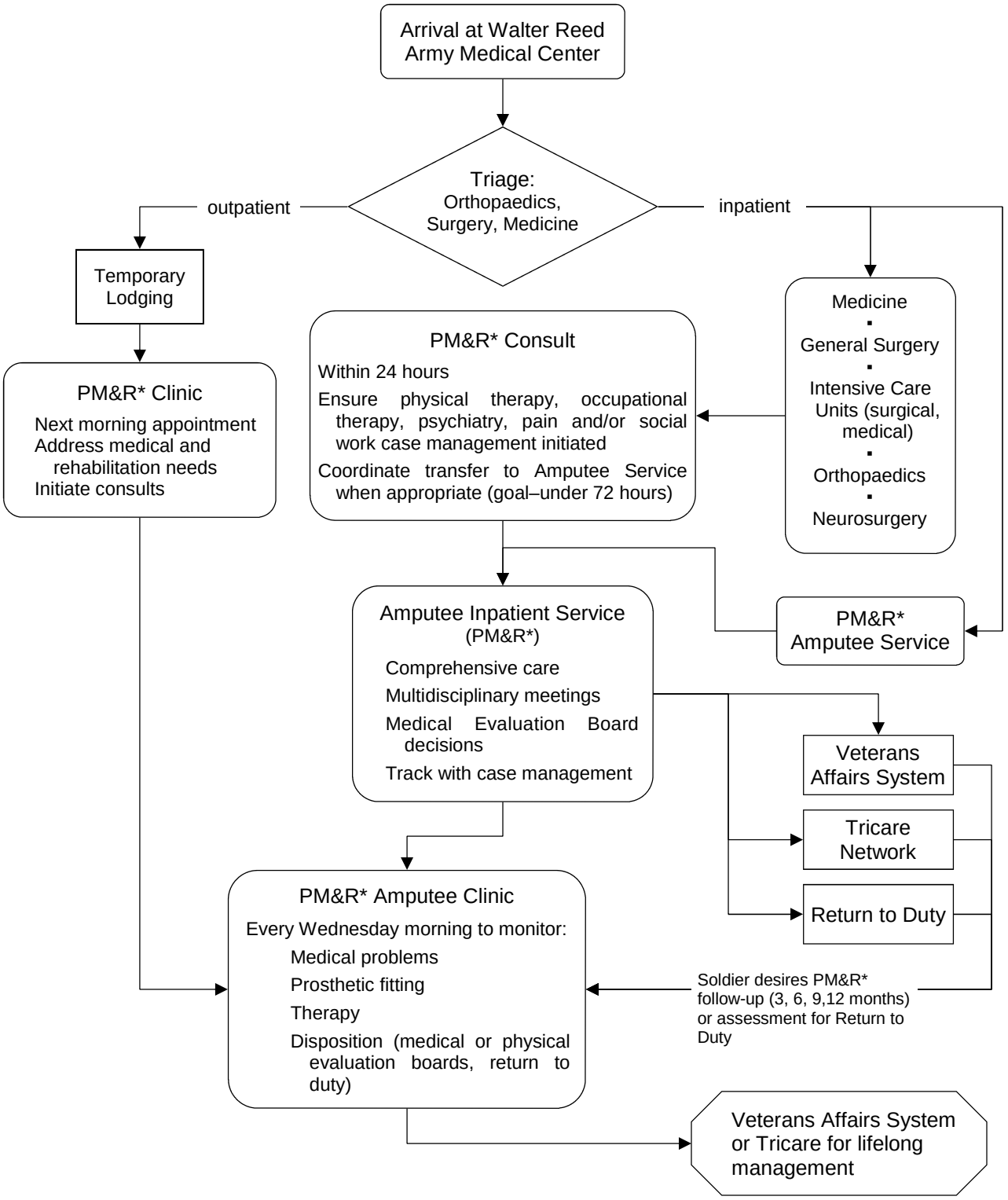
The PM&R Specialist is also skilled in performing electrodiagnostic testing to include nerve conduction studies (NCS) and needle electromyography (EMG). It is common for combat casualties to sustain multiple extremity wounds therefore jeopardizing the peripheral nervous system. A complete and accurate assessment of the peripheral nervous system is needed to make better medical, surgical, and rehabilitative decisions. It is often difficult to make accurate clinical assessments of the peripheral nervous system in combat casualties, given the extensive nature of the wounds, particularly those resulting from blast injuries. In these situations, electrodiagnostic testing can be very helpful. Determinations of central rather than peripheral nerve lesion, and root rather than plexus injury are possible by a skilled electrodiagnostician. Finally, results from electrodiagnostic testing provide input on developing prognosis.

Performing electrodiagnostic exams on the combat casualty is often challenging, considering the extent of soft tissue injury that has occurred. In addition, the presence of swelling and/or an external fixation device further increases the difficulty in performing these procedures and interpreting their results. It is therefore imperative for the PM&R specialist to have experience among this type of patient population.

AMBULATORY CASUALTIES

While much attention is paid to the multitrauma victim, a greater number of Soldiers return from theater with non-life-threatening medical problems. A significant amount of these problems involve the musculoskeletal system, especially the neck, back, shoulder, and knee. The majority of these injuries can be attributed to acute macro-trauma or repetitive micro-trauma. A significant portion of these patients, however, present with the exacerbation of a preexistent condition that was aggravated by the extraordinary physiological, psychological, and social demands and stress of combat.

Soldiers who are unable to continue with their combat mission because of a non-life-threatening injury are evacuated to the United States in a nonemergent status. The severity of injuries will dictate their triage status. Patients with less severe injuries may not arrive to an echelon V facility like WRAMC for several weeks or even months. Often these patients have already spent many days in transit before arriving at the echelon V facility. It is counterproductive to pursue an extensive medical evaluation of these patients upon their arrival in the middle of the night. It is much more effective and efficient to allow these ambulatory patients to get a good night's sleep, shower, and a meal prior to their evaluation. It is therefore imperative to identify a housing facility in reasonable proximity to the echelon V facility that is handicap accessible. In addition, prior arrangements must be made to have clothing, shoes,



Process flow for amputee care at the Walter Reed Army Medical Center

*Physical Medicine and Rehabilitation Service

and meals for these individuals upon arrival as they typically arrive with only the clothes they had when they were removed from the battlefield.

Ambulatory patients with musculoskeletal problems are instructed to report to the PM&R clinic the morning following their arrival, where a complete evaluation may be performed to include obtaining appropriate further studies (radiographic, laboratory, electrodiagnostic) as well as arranging referrals to other medical specialties or health care professionals. Prearrangements must be made with orthopaedics, physical therapy, occupational therapy, psychology/ psychiatry and social work to ensure easy patient flow, as these services will be most often needed. In addition, the evaluating PM&R specialist must have a good understanding of the air evacuation system and the requirements of the Patient Administration Division, which is responsible to track patients, issue their military orders, and make transportation arrangements for return to their home duty station or mobilization site.

The process for disposition decisions on Soldiers in today's modern army is extremely complex. Not only do these Soldiers present with different medical problems, but most also have unique social situations. This especially holds true for the National Guard and activated Army Reserve Soldiers, whose family may be in one state, their unit in another, and the demobilization site in even a third. It is generally best to move each Soldier to his/her demobilization site as quickly as possible, provided appropriate medical and therapy facilities are accessible and are arranged prior to the Soldier's departure from the echelon V facility. It is also generally best for the PM&R Specialist to ensure a complete and comprehensive diagnostic workup is completed and an appropriate treatment plan is established prior to allowing a Soldier to leave the echelon V facility. Conflicts arise as these injured Soldiers request convalescent leave to visit their loved ones. To address this issue, it is helpful to have an established policy to ensure Soldiers are treated fairly, but at the same time ensures accountability and tracking of Soldiers who may otherwise be lost to medical follow-up, or who may compromise their medical recovery if they are not compliant with the established treatment program.

In general, echelon V hospital convalescent leave should not be granted to these Soldiers unless they must return for follow-up at that facility. In this situation, the hospital command may grant up to 30 days as indicated by the type of injury. All other Soldiers should be returned to their demobilization site or duty station, where their rear unit may grant unit convalescent leave based on the needs of the unit as well as the availability of medical care at their leave location.

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PART 4
OCCUPATIONAL THERAPY

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Occupational therapy specialists are part of the larger team responsible for assisting Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF) Soldiers, Sailors, Airmen, Marines, Coast Guardsmen, and their families in rehabilitation for return to the highest level of function possible. Specifically, occupational therapy addresses deficits in activities of daily living, upper extremity motor performance

deficits secondary to injury or disease and occupational, or role performance deficits due to mental/behavioral health conditions. Occupational therapists and certified occupational therapy assistants work with a host of other professionals including, but not limited to, physical therapists, physiatrists, orthopedic and general surgeons, neurosurgeons, psychiatrists, social workers, nurse case managers, prosthetists, orthotists, and nurses to provide the highest quality of care throughout the treatment continuum.

INPATIENT OCCUPATIONAL THERAPY

Occupational therapy receives consults on OIF and OEF patients from surgical services, primarily orthopaedics, and general surgery. These consults usually are received within 24 hours of the patient being admitted to Walter Reed Army Medical Center. There is usually a warning or anticipatory notification from the Chief, Department of Orthopedics and Rehabilitation, on patients, particularly amputees, coming through the air evacuation system which provides some ability to project workload in amputee care.

Once consults are received, patients are evaluated within 24 hours. The team responsible for amputee care sees patients with upper and lower limb amputations. This team consists of 2 occupational therapists and 2 certified occupational therapy assistants. The team is augmented as needed with additional staff depending on the workload. The inpatient orthopedic and rehabilitation sections see patients with other traumatic injuries without amputations. Evaluation and treatments for physically injured patients are done both on the wards and in the Occupational Therapy Clinic. Patients evacuated from the theaters of operations with mental/behavioral health conditions are also seen on the ward in an inpatient status, and in the Occupational Therapy Clinic as outpatients.

Patients who sustain amputations as a result of their injuries require specialized care. This specialized care involves wound management, preprosthetic training and prosthetic training (basic and advanced). Factors involving residual limb care in terms of strengthening, regaining range of motion, and activities of daily living occur within each phase. Typically, amputee inpatients are in phase I preprosthetic care and training.

Those patients from OIF and OEF who sustained significant trauma not resulting in amputations are seen for the remediation of their deficits using standard occupational therapy methods and protocols. Initial evaluation and treatment is focused on assisting patients in reaching independence in activities of daily living, as well as the remediation of whatever musculoskeletal system has been affected.

Occupational therapy is part of the multidisciplinary team which sees those OIF and OEF patients who are undergoing treatment for mental and/or behavioral health conditions. Patients requiring inpatient care are seen in a milieu model of treatment. Outpatient OIF and OEF patients are seen as part of the Partial Hospitalization Program (PHP). This is a specialized outpatient program, which is part of the Psychiatry Department's Continuity Services. A life skill group from Occupational Therapy Services is a part of the PHP.

OUTPATIENT OCCUPATIONAL THERAPY

Most patients from OIF and OEF who are seen for outpatient care have been inpatients and are seen within 48 hours of discharge from the hospital. A patient who is evacuated to Walter Reed Army Medical Center as an outpatient and who is in need of Occupational Therapy is seen within 72 hours or less (usually), once a referral has been received. The evaluation and treatment process is similar to that of inpatients.

LESSONS LEARNED

The initial occupational therapy procedures for care of OIF and OEF patients had several inefficiencies. The amputee patients were evaluated and treated by multiple staff members, a process which lacked consistency and was somewhat inefficient.

Solution: A dedicated Occupational Therapy Amputee Section was created in late August 2003. This centralized the care to a group of therapists who provide consistent evaluation and treatment to all amputees. This team consisted of 2 occupational therapists and 2 certified occupational therapy assistants. There was one military therapist and one military occupational therapy assistant who will rotate with other military staff, allowing cross training of all occupational therapy staff over time. This team-based process allowed better synergy with the larger

Amputee Care Center working closely with prosthetists, physical therapists, and the physician staff. A protocol/treatment pathway was developed to provide an objective, reproducible method for amputee care with all upper extremity and lower extremity prosthetics, from preprosthetic training to discharge. Close coordination with the contract personnel from the Prosthetics Laboratory has resulted in a solid team approach in the upper extremity prosthetics fitting and training of Soldiers, and in the education of their family members.

Experience with the groups of patients from the Afghanistan Theater in the fall of 2001 through 2002 made it clear that the type of rehabilitation these patients required must include a more comprehensive effort in the area of activities of daily living.

Solution: In June 2003, renovations were completed for part of the Occupational Therapy Clinic to accommodate an apartment-type area for activity of daily living therapy. This area is heavily used, providing the OIF and OEF patients a place to practice skills necessary to return to independent functioning. The apartment allows patients to become independent in personal hygiene, transfers, cooking, household cleaning, and computer use.

CONCLUSION

The care of Soldiers from OIF and OEF is a high honor. The nature of battlefield injuries requires more complex and time-intensive evaluations and treatments. It also requires a strong multidisciplinary team of dedicated professionals to address all aspects of the Soldier who was injured in the defense of our country. The amount of effort necessary from the numerous professionals involved in the rehabilitation of these Soldiers cannot be measured in time or money. The true measurement is seen in the dedication and caring of a truly world class military medical team, from the battlefield to the medical center, with transition back to active duty, or to the Veterans Affairs system to assist with mainstreaming into the workforce as productive members of society.

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The Growth of the Profession of Occupational Therapy

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ABSTRACT

Occupational therapy is a frequently unknown and misunderstood profession. However, occupational therapy practitioners have a rich history in the US Army, from the inception of the profession to current challenges. The article is a chronicle of historical highlights of occupational therapy which discusses how this history is harmonious with that of occupational therapy in the US Army. In researching this topic, several concepts emerged: (1) occupational therapy grew from a belief that people need occupation, or activity, to remain healthy; (2) people learn the best through purposeful activity; (3) the number of occupational therapists in the US Army decreases during peacetime, but in time of war the benefit of this profession is recognized and its numbers increase; (4) although models of health care change, the primary focus of occupational therapy remains constant; and (5) there is a direct correlation between the philosophy of occupational therapy and the philosophy of treating Soldiers with combat stress reactions, a "go-to-war" mission of Army occupational therapy practitioners. As such, the management of these Soldiers is enhanced by the unique skills offered by this profession.

The roots of the profession of occupational therapy cannot be separated from the Army, for the history of the profession is intertwined with the history of military health care. Occupational therapy is the therapeutic use of purposeful and meaningful occupations to evaluate and restore function and independence. Inherent in this definition is the importance of occupation and purposeful activity. It is significant to note that these activities are not merely selected at random. Rather, the occupational therapy practitioner selects those activities that are best suited to the patient/Soldier's current level of function in order to ensure successful completion. This belief is the basis on which the profession was founded. Although the benefits of the use of activity have been acknowledged over the years, these lessons tend to be forgotten until a time of crisis. So too is the case with the development of occupational therapy. As this paper illustrates, the numbers of occupational therapists decline during times of peace. Then a war necessitates an increase, and training programs are developed in an attempt to fill the ranks.

AGE OF ENLIGHTENMENT — 1780S TO 1880S

The late 18th century heralded the "Age of Enlightenment and Moral Treatment." During this period, Dr Philippe Pinel used activities to "take the patient's thoughts away from their emotional problems and develop their abilities."[1] Pinel was a philosopher, scholar, natural scientist, and physician who saw the benefit of using activities in the treatment of the mentally ill. This was a drastic change from the accepted practice of placing people with mental illness in chains. It was felt that people needed a predictable routine to allow them to function optimally. In an effort to help them manage their environment, physical exercise, and work was believed essential and a necessary part of every institution's program.[1] Additionally, in a report signed by Dr Henry M. Hurd, the use of "occupation" was found to be a successful substitute for the use of restraints.[2]

By the end of the 1880s, Moral Treatment was diminishing in favor of a less costly form of custodial care.[3] Prior to its end though, a philosophy emerged that was based on Civil War experiences. This philosophy held that "the best means of preventing nostalgia [battle fatigue] was to provide occupation for the mind and body...."[4] This philosophy also stated that Soldiers placed in hospitals near their homes are more likely to develop nostalgia than those who remain near their units for treatment.[4] It is important to note that these ideas will be repeated in the 20th century with the development of combat stress control units, and will be discussed later. As this illustrates, even with the end of Moral Treatment there were still those who held firm to their belief in the benefit of occupation.

The period from 1890 to 1910 became known as the Arts and Crafts Movement. A great influence early in this period was the Hull House Labor Museum.[5] The general idea of this time was that "occupation should be used as a means of education to substitute for custodial care of the mentally ill."[5] To support this treatment, a course for play and occupation was established for nurses.[2] Just as the era of Moral Treatment ended, so did the Arts and Crafts Movement. By 1910, the number of medical schools was increasing and the focus of patient treatment turned to a more scientific study.[5] Occupational therapy was not yet a profession per se, but the foundation had been set. Just as the Coastal Redwood can grow from the roots of other redwoods, occupational therapy grew from the roots of other professions.

THE WAR TO END ALL WARS

Many of the founders of what was to be known as occupational therapy still believed that activity worked.[5] For example, a nurse named Susan Tracy published a paper in which a premium was placed on the "adoption of the occupation to the condition and natural tastes of the patient."[2] This was to set another piece of occupational therapy's foundation, that of adopting the activity to the needs and abilities of the patient. When the United States entered World War I (WWI) in 1917, this concept of re-educating people with the skills needed to enable them to become effective members of society was lauded as the best means of treatment.[6] In fact, the Civil Service Commission recognized occupational therapy as the profession that could provide this service, and admitted occupational therapists to serve as Reconstruction Aides in the Army Medical Department.[7]

The efforts of these first occupational therapists were to restore acute psychiatric casualties and patients with impaired motor function by teaching crafts. These pioneers in the field were called "nondescript" as few people knew what they did,[6] which continues to be problematic today! Apparently their benefit was felt, though, as 24 civilian Reconstruction Aides were deployed to France in support of the war effort.[7] This first reconditioning program emphasized that activity should be prescribed early, as with our current doctrine of combat stress control.[6]

In 1918, the Army Surgeon General expanded the emergency training programs to seven civilian institutions in an effort to fill the need for Reconstruction Aides.[7] In addition to working with neuropyschiatric patients, the profession soon to be known as occupational therapy treated people with amputations, blindness, head and nerve injuries, osteomyelitits, and tuberculosis.[6] The idea of providing activity appropriate to the needs of the patients was still vital. In 1919, Army MAJ Bird T. Baldwin described the use of activity analysis, which was how the appropriateness of an activity was determined. This strong supporter of the profession stated that the purpose of occupational therapy is to "help each patient find himself and function again as a complete man physically, socially, educationally, and economically."[8] The roots of occupational therapy began to establish themselves and the foundation of a new profession was set. By the end of WWI, the number of occupational therapy Reconstruction Aides serving was an astounding 455, but by 1919 most occupational therapists employed by the Army were discharged.[7]

THE WORLD AT PEACE — A PROFESSION GROWS

In an effort to treat the veterans of WWI, the emphasis was on vocational rehabilitation, with the Federal Board of Vocational Rehabilitation providing occupational therapy services.[7] However, by 1920 the therapeutic use of work was part of physical rehabilitation instead of vocational rehabilitation, which resulted in occupational therapists being cut-off from work related programs.[5] Even though the number of occupational therapists serving with the Army diminished, the profession did not die—its roots spread and the trunk that was to become occupational therapy began to grow.

A major step toward this growth occurred in 1922 when Dr Adolph Meyer wrote what was to become the philosophy of the profession.[2] Three main ideas served as the basis of this philosophy. One was that people need a balance of work, rest, play, and sleep in order to function with normal lives.[9] When this balance is disrupted, be it through disease, injury, or combat, dysfunction results. The second idea was that of the mind-body connection.[2] Dr Meyer supported the less popular belief that the mind and the body could not be separated, that one affected the other in relation to

illness. The third idea was that people learn best by doing things, or through occupation.[9] This described the beneficial use of appropriate activity that had been inherent in the treatment of people since the late 18th century.

The profession saw other changes as well as this roller coaster of events thundered onward. The term "Reconstruction Aides" was changed in 1926 to "physiotherapy" and "occupational therapy."[6] Only a few years later, during the l930s, a model based on the orthopedic needs of the patient began to evolve.[5] Occupational therapists were then also working with muscle strengthening and maintaining joint range of motion. As the Depression ended and the nation was recovering, changes were experienced in occupational therapy as well. In 1933, the training course at Walter Reed Army Medical Center was abolished secondary to a lack of funds, and occupational therapy programs and personnel in all permanent Army hospitals were reduced to a minimum.[9]

WORLD WAR II

Once again history repeats itself. The nation found itself at war and the profession of occupational therapy found its numbers had dwindled to almost nothing. When the Japanese attacked Pearl Harbor on December 7, 1941, there were only 9 occupational therapy practitioners affiliated with the Army, and only 3 of those were qualified registered therapists.[9] It comes as no surprise that the big concern at this time was the recruitment of qualified therapists and the establishment of accredited training programs to meet this need.[10] Although the number of personnel was small, the benefits of the profession were great. To continue our analogy with the Coastal Redwood, the roots had spread and established themselves, and the trunk began to shoot upward.

The period during World War II (WWII) found several supporters of occupational therapy. Among them was a physician, MAJ Walter Barton. He strongly believed that "work, rest, and play activities represented the essential triad for the restoration of health," and recommended occupational therapy departments establish progressive activity programs.[10]

"Occupational therapy," he noted, "should be applied at all points of treatment from forward the echelon aid station to the last point of evacuation in the psychiatric section of a named general hospital."[11] The importance of meaningful activity and constructive work was continually stressed as a method of treating the restlessness generated from inactivity. People want to feel useful. It was frequently observed that Soldiers had an intuitive need for occupation, and became willing to perform work if they viewed it at least indirectly supportive of the war effort.[10]

Another supporter was LTC Alan Challman (Medical Corps) and the consultant to neuropsychiatry in the southwest Pacific area. In 1942, he was charged to review the organization of psychiatric services and create an approach that could reverse an alarming trend: the Surgeon General's office determined that "psychiatric casualties constituted nearly 40% of the medical discharges being processed by the Army - a situation viewed as intolerable and unnecessary."[10] LTC Challman found that Soldiers with mental disabilities could be better treated and more appropriately diagnosed, with more of them restored to duty, if they were given specialized help that included occupational therapy. This was based on his finding that "patients who had been given up for lost by the ward officer made complete recoveries when provided purposeful activity *suited to their abilities* [italics added]."[10]

Even this level of support was not enough to counteract the low number of qualified occupational therapists, and it was determined early in the war that they would not be military personnel. This meant that all occupational therapy activities would be confined to the Zone of the Interior, which in reality hindered the recruitment of adequate personnel.[9] Like so many Americans, occupational therapists wanted to serve their country. In fact, the actual need for occupational therapists did not meet the perceived need. In response to this lack of qualified occupational therapists, a War Emergency Course began in July 1944 by the Occupational Therapy branch of the Surgeon General's Office in conjunction with the American Occupational Therapy Association and War Manpower Commission.[6] This was an accelerated 12-month program, with more hours devoted to the sciences, clinical conditions, and the theory of occupational therapy than to arts and crafts. The need for a strong knowledge base in psychiatric conditions was recognized, but, due to the short training period, it was made a prerequisite to attend. In the interim,

occupational therapists supervised Red Cross volunteers in the craft program so the provision of this vital activity to the Soldiers was not lost.[5] However, by 1945 all treatment was to be of a functional nature, not merely diversional. Crafts were no longer confined to the bed, but brought to the clinics.[6] This meant that all treatment, even the use of crafts, needed to be developed and/or supervised by a skilled occupational therapist. This created an even greater strain on the small number of occupational therapists.

Due to the War Emergency Course, the number of occupational therapists continued to rise, and the types of programs provided expanded in number. The Table illustrates some of the areas of treatment and the type of treatment provided by occupational therapists toward the end of WWII. Although a variety of conditions were being treated, the basic premise of using purposeful activity graded to the individual's current level of function remained the same. Additionally, the areas of treatment were divided into 4 main programs:[9]

Types of Occupational Therapy Treatment in 1945

Diagnosis	Treatment
Head injury	Cognitive retraining, language training
Orthopedic	Exercise through purposeful activity
Plastic surgery	Functional therapy, diversion therapy
General medical (polio, cardiac, etc)	Graded activities to create a sense of independence. Hobby development, muscle tone maintenance, functional use of upper extremity, restoration of self-confidence
Newly blinded, deaf	Orientation, activities to create a sense of independence and self-confidence in performance of self-care, etc
Spinal cord injury, paralysis	Adaptation to allow performance of daily activities independently, improve strength in functional muscles
Amputee	Addressed the psychological aspect, functional use of prosthesis and remaining upper extremity
Tropical disease	Mainly activities to counter boredom, apathy, anxiety

1. Functional Programs: These provided education and training in self-care, and addressed general body weakness, joint range of motion, and decreased respiratory tolerance.

2. Neuropsychiatric Programs: Persons in these programs were not only psychiatric patients, but also those with "psychoneurosis" secondary to the stress of war. Many of the ideas in these programs would be seen again in the doctrine for the management of combat stress reactions,[12] such as the need for immediate treatment being essential. The purpose of these programs was multifaceted: (1) to "guide mental attitudes into healthy channels," (2) promote the desire to get well, (3) restore self-confidence and a sense of security, (4) provide encouragement of the Soldier improving, (5) establish and maintain good work habits, and (6) afford an opportunity for socialization. One can recognize in these ideas similarities to the Army's current doctrine on the management of Soldiers with battle fatigue—rest, replenishment of physiological needs, reassurance of normalcy and return to duty, and restoration of confidence.[12]

3. Industrial Therapy Programs: These programs were provided as the patient progressed. They applied to medical, surgical, and neuropsychiatric patients, addressing the physical as well as the psychological needs. The purpose was not only to increase general muscle tone and joint range of motion, but also to combat the effects of a prolonged hospitalization. In this program, patients were able to improve their tolerance to work, establish good work habits, and stimulate mental alertness.

4. Diversional Programs: The purpose of these programs was to divert the patient from thinking of himself. However, the benefits did not stop there. They stimulated the patient's interest and provided constructive use of leisure time. By providing an opportunity for self-expression, the Soldier's morale was sustained. In addition, the patient's work habits were maintained and his general physical fitness would improve.

A Brief Peace—Great Progress

In the 5 years between wars there were 2 major accomplishments for the profession. Because of the diversity of programs offered by occupational therapy, and the recognition of the benefits of the services provided, occupational therapists finally became a part of the Army. In 1947, occupational therapists were commissioned as officers in the US Army with the establishment of the Women's Medical Specialist Corps, which also included physical therapists and dietitians.[6] Then, in 1949, postgraduate programs for occupational therapists were reinstated for military personnel.[7] This is the first time a training program for occupational therapy was instituted before the need became great. As far as the military was concerned, occupational therapy had become an entity unto itself, like the Coastal Redwood that grew into a mature tree. Nevertheless, the years of peace were short-lived as the US became involved with the Korean War.

The "Forgotten War" and Beyond

The period of 1950–1953 saw a drastic slowing of the growth and development of occupational therapy in the US Army. The number was down from the 899 therapists seen at the end of WWII, to around 90 women serving in 1953.[6] One change seen, however, was the resurgence of the dominance of the psychiatric model.[5] After the truce to halt the Korean War was signed, occupational therapists continued to work primarily in general hospitals. By 1954, they were working in additional areas of treatment such as with burn patients and those involved in substance abuse.[13] Occupational therapists also returned to being a large part of work related programs.[5]

The biggest change seen during this period was in 1955, when men were first allowed to serve as occupational therapists. Of course this forced a change in the name from the Women's Medical Specialist Corps to the Army Medical Specialist Corps.[7]

A Turbulent Decade

The 1960s were a time of turbulence and change, not only for the American society in general but for the profession of occupational therapy as well. It is no surprise that, with the reemergence of the psychiatric model during the last decade, humanism returned. The effect this had on civilian occupational therapists was drastic, for the way they treated their patients had to change as more people were deinstitutionalized.[5] Once again, Army occupational therapists saw a change in their numbers. Occupational therapy authorizations decreased in order to make slots available for other Army officers. The number of occupational therapists dropped to a mere 64 in 1960.[6]

The first half of the 1960s saw a buildup of US military advisors in Vietnam.[14] The training of occupational therapists witnessed a similar buildup with the start of a student occupational therapy program in 1962.[7] The decade ended with the questioning of many established beliefs. The idea of humanism was being challenged once again in 1970. It was felt to be "unscientific and immeasurable,"[5] and a medical model was envisioned as a replacement. As a result, the role of Army occupational therapy developed a medical focus as well. In the mid 1970s a skill identifier was established which, with additional training, allowed occupational therapists to serve as physician extenders in the treatment of upper extremity injuries.[13] But even with this emphasis on the medical model, the value of occupation and activity was still recognized. A Life Skills program which addressed the needs of Soldiers with psychiatric and stress disorders was developed by occupational therapy practitioners at the Eisenhower Army Medical Center, Fort Gordon, Georgia, in 1974. The use of occupation as a method to improve the performance of these Soldiers was paramount.[15]

Post-Vietnam

In the year after the fall of Saigon, the Army Student Occupational Therapy program also ended due to the need to reallocate active duty slots.[7] The occupational therapists used this time to their advantage and developed a philosophy for their profession in 1980. This philosophy was much the same as the one written by Dr Adolph Meyer in 1922, for the foundation had not changed over the years. It emphasized the importance of the mind-body connection in the disease process, and how occupational therapy addresses all aspects of an individual. Role performance was discussed from the perspective of maintaining a balance of work, rest, play, and sleep. Skill acquisition was believed to occur through purposeful activity and repetition of relevant tasks.[16] Occupational therapists believed then, as we do today, that "the capacity to resume role performance may be achieved even though symptoms remain," namely through adaptation.[10]

An interest in work programs returned once again. Instead of merely providing work activities for Soldiers, this concept had matured to where work hardening programs and job evaluations were performed as well.[5] Occupational therapists could evaluate the skills necessary for a Soldier to perform a job, adapt the treatment to match the Soldier's current level of function, and prepare that Soldier to return to duty. The year 1980 also saw an increased awareness of physical fitness in the Army. Occupational therapists joined in that effort as they became active in programs such as stress management and weight control.[13]

Some interesting concepts reemerged in 1984, when the Army Medical Department identified combat stress control as a separate functional mission area. These concepts were formally presented in *Field Manual 8-51*[12] under the premise that the Soldier should be treated in the proximity of his unit, immediately, with the expectation of his return to duty, and utilizing simple methods of management. This was accomplished using what at that time were three main principles: reconstitution, reorientation, and reintegration. Soldiers with combat stress reactions severe enough to affect job performance would perform duty-related activities in work assignments. The occupational therapy practitioner's unique role in the management of these Soldiers is to "precipitate adaptive and effective occupational performance by engaging them in therapeutic occupation [occupational therapy] which supports their military identity, reinforces ingrained adaptive occupational skills, enhances their sense of competency, supports their socialized military values, and maintains their physical conditioning."[17] This allowed them to view themselves as contributing to the mission, which in turn would hasten their recovery and return to duty. In other words, the Soldiers would be performing occupational therapy! Watson and Thome[18] recognized this similarity between Army doctrine and occupational therapy philosophy, and proposed a program called "Project ABLE." This was a task-directed behavior program designed to improve the Soldier's job performance. A revised doctrine of combat stress control was published in 1994, and some of the principles were updated and changed from the previous edition.[12] The methods of the management of casualties was expanded and clarified, but the primary concepts remained the same.

However, before the Army could officially initiate these management principles, Desert Shield/Desert Storm erupted. During this period, active duty occupational therapy practitioners were deployed to the Persian Gulf and many Reservists were called to active duty to fill stateside assignments.[7] LTC Mary Laedtke was one of the occupational therapy practitioners deployed to the Persian Gulf. While assigned to the 528th Medical Detachment (Psychiatric), she utilized the principles of combat stress control in working with Soldiers. She reported that the use of "work and other occupations [which were carefully selected to meet the Soldier's current ability] to return the combat-stressed Soldier to duty proved to be an integral part of the restoration process."[7] Since occupational therapy is the only health care discipline to approach intervention in this manner, LTC Laedtke was able to demonstrate the benefits of occupational therapy in an active theater of operations.

THE WAR ON TERRORISM

The events of September 11, 2001 changed the lives of countless people. Those involved in the profession of occupational therapy in the US military were no exception. In his article,[19] Army occupational therapist CPT Roger Bannon relates his experiences as a member of a Special Medical Augmentation Response Team for stress management. In the days that followed the attack at the Pentagon, CPT Bannon utilized his training and experience in combat stress control and critical incident stress management to help the victims begin their recovery.

Operation Enduring Freedom provided opportunities for occupational therapy practitioners to further demonstrate the unique skills of their profession. As a member of the 528th Medical Detachment (Combat Stress Control) from Fort Bragg, North Carolina, Army CPT Robert Montz served on a team that provided mental health and preventive services in Uzbekistan, Afghanistan, and Pakistan. CPT Montz assisted in providing briefings such as stress management, handling human remains, and redeployment. He also regularly visited and walked through the supported units' areas, where he was able to observe the Soldiers at work and assess how the Soldiers were functioning.[20]

Another unique opportunity for occupational therapy emerged that year as the 85th Medical Detachment (Combat Stress Control) at Fort Hood, Texas, began preparations to deploy a Prevention Team to Guantanamo Bay, Cuba, to support the Joint Task Force. The team was led by 2 occupational therapy professionals, the author, an occupational therapist, and occupational therapy assistant, SSGT RB Howard. This was the first time an actual combat stress control prevention program for service members was developed and implemented on this small Naval installation. In addition to the typical work performed by combat stress control teams, these occupational therapy practitioners were able to bring the unique perspective of occupational therapy to the mission. For example, while conducting the usual "walk-abouts" performed in conjunction with preventive combat stress control, I would work with the service members to determine the stressors, mental, physical, and emotional, that were present in the performance of their job. Education and activities meaningful to the service members were used to address the various stressors that arose. This would sometimes entail structuring the environment and/or the job to ensure successful completion of the task, and, in one instance, ergonomic recommendations were made to make the job safer and more efficient.

As this article is written, many occupational therapy practitioners are serving in Kuwait and Iraq in support of Operation Iraqi Freedom. In addition to combat stress control teams, occupational therapists are working in field hospitals and on a medical brigade staff, active duty and reserve components. Continuity of care is ensured as the service members evacuated from theater receive occupational therapy at medical treatment facilities in Germany and the United States. These occupational therapy practitioners are providing vital services in the treatment of upper extremity and spinal cord injuries, amputations, and psychiatry.

TODAY AND INTO THE FUTURE

Occupational therapy today continues to evolve to meet the needs of changing times. The 79 occupational therapists currently on active duty are serving in combat stress control units, medical centers, medical activities, as Professional Officer Fillers (PROFIS), and on stress management Special Medical Augmentation Response Teams. In addition to the deployments discussed above, occupational therapists have been deployed to support missions to areas such as Bosnia-Herzegovina, Cuba, Peru, Russia, Columbia, Honduras, El Salvador, Sri Lanka, and to South America following Hurricane Mitch. Today's occupational therapists are working with Soldiers, family members, and retirees with a variety of problems—orthopedic, neurological, psychological, and stress. Occupational therapists have commanded medical units, from company level to a medical facility.

The profession's ability to address a myriad of diseases and injuries has contributed to this wide range of positions. As history vacillated between the use of medical and humanistic models, so too did the profession of occupational therapy. This vacillation continues today as disciplines in the health care field debate the best way to treat patients. Even though the role of occupational therapy has changed over the years, the profession eventually returns to its roots of occupation and the use of purposeful activity, the belief in the importance of treating the entire person, and the belief in the benefit of maintaining a balance of rest, work, play, and sleep. This premise allows occupational therapists to "play the role of mediator between the sciences [medical model] and the humanities [humanistic model], and between the high technology of diagnosis and treatment and the art of human caring."[21]

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Medical Care in the Sustainment Brigade

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INTRODUCTION

Military logistics doctrine conceived to support traditional conflict with a clearly defined front and rear has recently evolved to sustain the fight against an enemy without defined real estate. The nonlinear battlefield demands quickly mobile and self-sufficient units. Modularity (the deployment of units as smaller standalone pieces) emerged, resulting in a shuffling of support and medical assets. Combat units, renamed brigade combat teams (BCT), assumed control over their own logistical and medical resources, decentralizing ownership out of the former division support brigade (DISCOM). This internal control enables the BCTs to move easily as single self-sustaining units. The DISCOM, once the command and control center of all the division's logistical and medical support, assumed a new role and new name—the sustainment brigade. Stepping up to a corps or area support role, while maintaining some responsibility to collocated divisional elements, the sustainment brigade assumes command, control and responsibility for logistical support to meet additional needs of the division and for all collocated units which are without organic support elements.

In keeping with the concept of modularity, a sustainment brigade owns whatever pieces are needed to provide support in a given area. Unique in this ability to gain and lose assets while moving in and out of a war zone, the sustainment brigade is usually a headquarters element with a few hundred Soldiers while not deployed. As it moves into a theater, new units, identified by the headquarters element during predeployment planning and site visits, come under the umbrella of the sustainment brigade command. As it redeploys home, these units, many mobilized National Guard and Army Reserve, are shed and deactivated. Planning is central to the process of sustainment brigade deployment as it is the mechanism by which the correct logistical resources are established in an area.

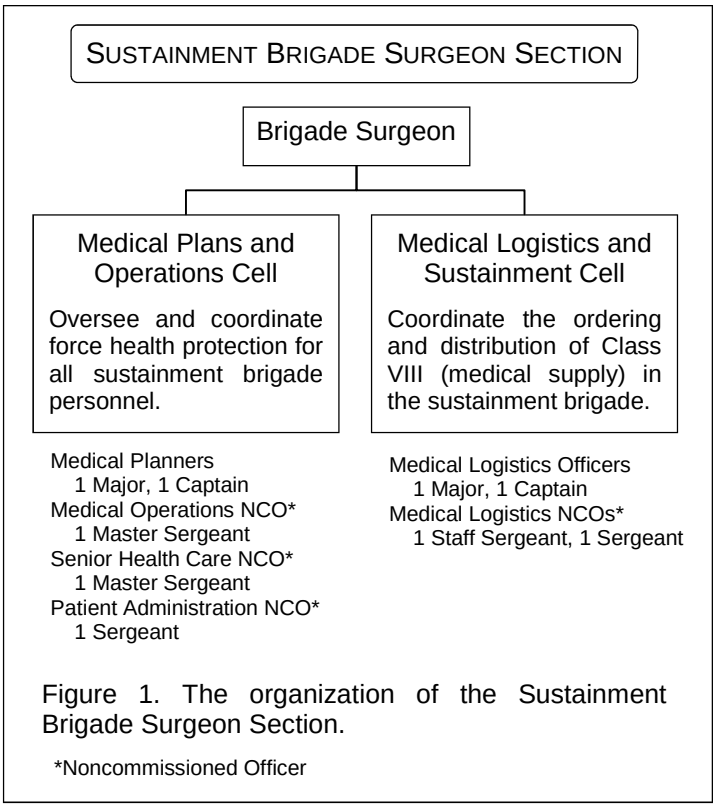

Figure 1. The organization of the Sustainment Brigade Surgeon Section.

*Noncommissioned Officer

SUSTAINMENT BRIGADE MEDICAL SUPPORT

The sustainment brigade concept creates specific challenges for medical support. The sustainment brigade's medical element consists of a planning section and a small medical platoon. The medical oversight and planning section is headed by a physician, the brigade surgeon, who is usually a senior captain or major and is residency trained in one of several key specialties. Within the surgeon's section, shown in Figure 1, there are 2 cells, medical plans and operations and medical logistics and sustainment, each with a staff of senior noncommissioned officers and medical service corps officers. The sustainment brigade's medical platoon, shown in Figure 2, consists of a headquarters element, a treatment squad, and an ambulance squad. Within this structure are the medical providers and medics to support level I, or emergency care and sick call services to personnel within the

sustainment brigade headquarters section, a population of about 400 people. When the sustainment brigade deploys and assumes command and control of several battalions, depending on its area support mission, it grows several thousands in strength.

There is little the sustainment brigade cannot do for itself, except provide adequate medical care to all its deployed units without additional help. This is because most units that deploy under the sustainment brigade in war do not come with their own medical assets. Among the sustainment brigade resources, medical support is nearly absent (except for the small medical platoon). Medical services for the additional sustainment brigade units must be coordinated by the sustainment brigade surgeon's planning section.

The command and control of corps level health service support is the responsibility of the medical support command, a separate unit with its own command element. As the sustainment brigade prepares for deployment, additional medical assets can be arranged through the medical support command, depending upon the number of additional Soldiers joining the unit and the needs of the units in the area supported. A subordinate unit of the medical support command, the multifunctional medical brigade (MMB), provides area medical support much in the same way the sustainment brigade takes responsibility for logistics. It too is a modular style unit with the variety of medical assets tailored to meet the area's medical needs. Accurate and well-coordinated planning with both the medical support command and MMB is critical to ensure adequate medical support for sustainment brigade Soldiers. In the case of medical planning, the focus of the sustainment brigade surgeon section is turned inward toward caring for those Soldiers.

Therein lies the critical issue concerning medical support in sustainment brigades. Whereas the sustainment brigade provides additional area logistical support, it is the medical support command that coordinates and provides the area medical support. The sustainment brigade and medical support command may interact in any different number of ways, depending on the layout of the theater. Pieces of the medical support command may be allocated to the sustainment brigade, the sustainment brigade may use assets of the medical support command that happen to be collocated, or the medical support command might

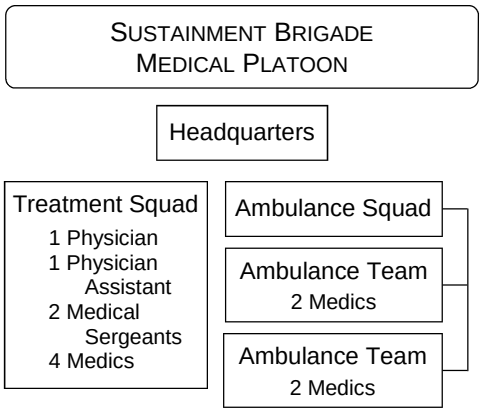

Figure 2. The Sustainment Brigade Medical Platoon is organized, staffed, and equipped to provide level I, or emergency care and sick call services only to personnel within the sustainment brigade headquarters section, a population of about 400 people. As structured, it cannot provide adequate services to the additional units that are assigned to the brigade when it is deployed.

be under operational control of the sustainment brigade. In theory, the sustainment brigade and medical support command are 2 separate support units operating as interdependent entities, the sustainment brigade providing necessary nonmedical supplies and services to the medical support command which provides the additional medical care absent in the sustainment brigade. However, coordinated planning between 2 separate commands is complex and, in a dynamic theater, medical support command assets may not be geographically available to support sustainment brigade Soldiers.

In a reversal of the support concept, the sustainment brigade may come to rely on the local BCT to care for its Soldiers since the BCT deploys with robust medical assets. The medical element of the BCT looks much like its predecessor in the former forward support battalion/main support battalion, with a medical company in the support battalion and a medical platoon (Figure 3) in each combat battalion. By design, the BCT has medics, physicians, and physician assistants imbedded in the structure of its battalions. The medical company provides level II care, by definition, higher-level care with x-ray, laboratory,

dental, mental health, pharmacy, and patient hold capabilities. However, a system whereby a sustainment brigade relies on a BCT for level I and/or level II medical care can present a problem as the BCT is not designed to be an area asset. Slices may need to move to support the fight, taking with them some (or most) medical assets. It is a situation that can adversely affect those sustainment brigade Soldiers who rely on the BCT's medical resources when combat missions dictate relocation of those same assets.

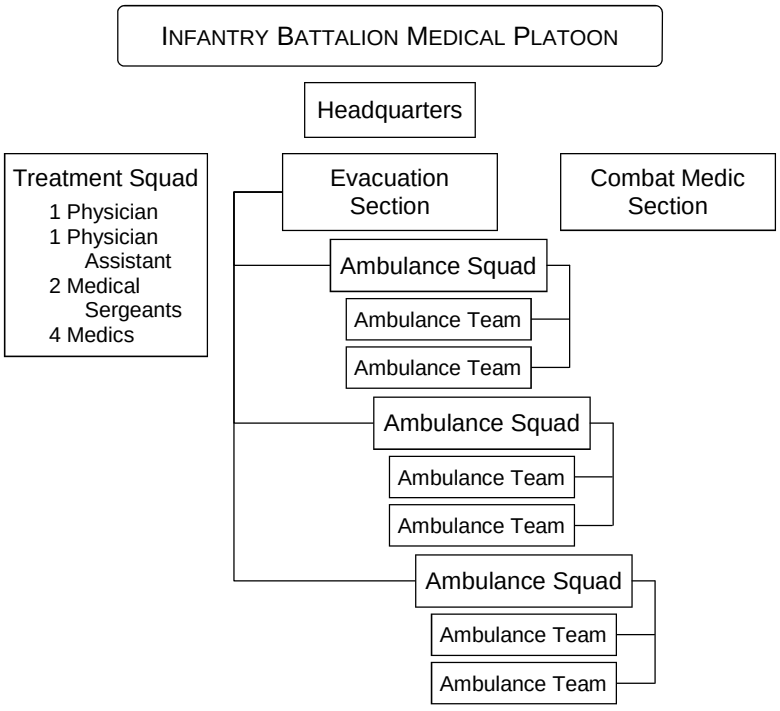

Figure 3. Each infantry battalion in a brigade combat team has a medical platoon to provide level I care (sick call, emergency, acute trauma care) to the battalion Soldiers. Each ambulance team has either 2 or 3 medics, depending on the transport vehicles. The combat medic section provides one combat medic per infantry platoon throughout the battalion.

In the planning phases before deployment, sustainment brigade medical planners must decide how much health service support is required for their troops. This support must be reliable and responsive to the medical needs of the sustainment brigade, the population of which may include newly activated Army Reserve and National Guard Soldiers representing a different medical demographic than active duty troops. Lacking clear-cut guidelines to dictate provider-to-patient ratios, planning can be difficult. One model to use is the medical personnel structure of the BCT where, generally speaking, provider (physician or physician assistant) to patient ratios in a deployed setting are estimated at 1/400 to 1/600 Soldiers. Combat casualty estimates are different in a fighting brigade as compared to the support brigade, but similarities exist for level I sick call services.

HERE AND NOW

The first sustainment brigades were created in Iraq in a mature theater, transforming from the DISCOM. Medical support was well established in most areas as units settled onto built up forward operating bases (FOBs) with medical clinics or hospitals. In the future, as sustainment brigades face establishing new theaters from the ground up, the onus will rest heavily on the medical support command and sustainment brigade medical planning sections to ensure adequate medical services for sustainment brigade personnel moving into theater. As early setup of the theater support structure is a central mission of the sustainment brigade, future leaders must plan carefully for medical support of the early forward logistical teams. Otherwise, level I and II medical care for sustainment brigade Soldiers, especially in the phases before the deployment of BCTs, will be absent.

In Iraq, the medical support command (known as the Medical Task Force) operates independently from the sustainment brigades with a separate command structure. Health care for sustainment brigade Soldiers in each region evolved differently based on surrounding resources. The 82nd sustainment brigade in Southern Iraq (FOB Talill) obtains level I and II care from a neighboring BCT, the 45th Sustainment Brigade in Northern Iraq (FOB Qwest) provides level I and II area medical support for personnel on their FOB, with the augmentation of laboratory and x-ray technicians and one medical provider provided by the medical support command. The 15th Sustainment Brigade in Central Iraq (FOB Taji) operates a level I medical clinic providing care for 2 battalions of the sustainment brigade using only the organic assets of the headquarters medical platoon while relying on level II assets of the local BCTs. Three additional

battalions of the 15th Sustainment Brigade operating out of different FOBs and receive medical care at collocated BCTs or from the area support medical company, an element of the medical support command.

There are unique challenges facing the sustainment brigades in Iraq. The 45th Sustainment Brigade's medical platoon, while augmented by the medical support command, has a significantly leaner staffing than a BCT medical company's level II facility. Comparing only medical providers, in this instance, a BCT with a similar mission in theater would have an additional physician and physician assistant to care for the same patient population. The 15th Sustainment Brigade has half a brigade of Soldiers located throughout Iraq without imbedded organic medical personnel. Tracking illness trends, evaluating environmental and health threats, and providing the full spectrum of health oversight to these units, all of which are the responsibility of the surgeon section, are difficult without onsite medical assets within the brigade and battalion command structure.

Conclusion and Recommendations for the Future

Outlining the role of the sustainment brigade in area medical support and the definition of assets to care for sustainment brigade Soldiers are still works in progress. While the new sustainment brigade may share many of the logistics and supply responsibilities of the former DISCOM, it shed all but a skeleton of medical assets during transformation. The sustainment brigade's reliance on outside elements to provide its Soldiers and customers medical support is somewhat counterintuitive. Modularity of medical assets must evolve to coordinate with the sustainment brigade and effectively fill in the gaps.

A central concept of combat health support is the maintenance of an operational force in a deployed setting. For a population as large as that of the sustainment brigade in theater, such responsibility should be assumed by medical providers and support personnel internal to the brigade. Level II medical capabilities should be under the operational command and control of the brigade commander and surgeon section when the sustainment brigade moves into theater. Medical care for the thousands of Soldiers in the sustainment brigade cannot be adequately provided by units that do not have a direct interest in health care trends of the sustainment brigade. Additional slices of medical care provided by the medical support command should be attached to the sustainment brigade on a ratio that models the BCT medical organization.

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Evidence-Based Medicine: The Way to Cost-Effective, Quality Medical Care

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The Declaration of Independence highlights the key enduring principles for all Americans—Life, Liberty, and the Pursuit of Happiness. These enduring principles set the foundation for the basic rights and expectations of all US citizens. Americans want and deserve a healthcare system that ensures quality medical care that is both accessible and affordable. What they now have is a disorganized and unsustainable system with increasingly serious problems of access, cost, and quality. In 2005, the United States spent $1.9 trillion (16% of the gross domestic product (GDP)) on medical care, and it is expected to spend $4.0 trillion (20% of the GDP) in 2015.[1] Can Americans afford this rising cost? Already an estimated 45 million people (15% of the population) are uninsured in the United States. Getting control of the healthcare system is crucial to national security, especially in today's environment of volatility, uncertainty, complexity, and ambiguity. President Bush stated in his 2006 State of the Union Address, "Keeping America competitive requires affordable health care…for all Americans, we must confront the rising cost of care…"[2] The US healthcare system is transitioning into evidence-based medicine (EBM), in which good evidence is used to stimulate effective performance by providers and organizations. This paper focuses on the utilization of EBM as a strategy to ensure high-quality, cost-effective medical care in an effort to reverse the momentum of ever rising costs.

BACKGROUND

The US healthcare system has been proclaimed as the best in the world. The advancements in technology, pharmaceuticals, procedures, and integration of the industry have led the world. However, has all of this guaranteed the best care in the world? The United States has by far the world's most expensive health care system, based on health expenditures per capita and on total expenditures as a percentage of GDP. According to data from the Organization for Economic Cooperation and Development (OECD), per capita health spending was about 2½ times the OECD median, and health spending as a percentage of GDP was twice the median for the 29 member OECD countries.[3] In 2000, the World Health Organization (WHO) released a report which stated that a good health system is based on good health, fairness in financing, and responsiveness. In spite of the massive spending on health care, the US does not rank number one overall in the world. With regards to good health, the US infant mortality rate of 7.0 deaths/1,000 live births was higher than the mean rate of 6.1 for OECD countries, and the US disability-adjusted life expectancy ranks 24th of the 29 members.[4] The US ranked the lowest of the OECD countries with regard to fairness in financing, a measurement of the degree in which financial contributions to the health system are distributed equitably across the population. According to the WHO, the United States and South Africa are the only 2 countries in the developed world that do not provide health care for all citizens.[5] In contrast, the US health system ranked number one of the OECD countries in responsiveness, the extent to which caregivers are responsive to patient expectations.

As evidenced by the WHO good health system report, American patients do feel that their caregivers are responsive to their expectations. Lamm stated that, "The doctor-patient relationship is the most important perspective in health care. It is a healing perspective, concentrating on the patient, focusing modern skills in a 2,000 year-old tradition that makes the doctor advocate a fiduciary, healer, and confidant for the patient."[6] The physician is the key to helping resolve the ever-increasing cost of health care in the US. Patients trust their physicians, and physicians determine what therapies and interventions are necessary for their patients. Physicians have been trained to offer their patients the best medicine has to offer, no matter the cost. Even though the year 2000

US standard for medical care is good and is practiced by most of the world at a lower cost, the US standard for medical care in the year 2006 is better and more expensive. The cost of new therapies, medications, and procedures are always more expensive when they are first introduced, due to the added research and development cost, but is it that much better for outcomes? Physicians are caught between being patient advocates in providing the best quality medical care, and being cost-effective for the payers (government, employers, taxpayers, individuals, and insurance and managed care companies).

WHAT IS EVIDENCE-BASED MEDICINE?

A tool available to physicians to provide high quality and cost-effective medical care is EBM. Philosophical origins of EBM extend to mid-19th century Paris. It was given its brand name in 1992 by a medical group at Canada's McMaster University which taught medical students the new paradigm.[7] EBM is defined as "the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients."[8] This concept gives new vigor to the long-established principle that health care should be based on solid scientific evidence, rather than on tradition and uncontrolled clinical experience. The physician must balance research evidence with their knowledge, judgment, and experience to the uniquely different individual needs of their patients. Without current best evidence, practice risks become rapidly out of date and can adversely affect the patient.

The pursuit of EBM is at the center for improvement of health care in the United States. Quality measurement systems use science-based indicators to evaluate proper processes of patient care. For example, the ORYX™ measurement requirements of the Joint Commission on Accreditation of Health Care Organizations, the Health Employer Data and Information Sets (measures of the National Committee on Quality Assurance), and the Quality Improvement Organizations for the Centers for Medicare and Medicaid Services all use science-based indicators.[9] Medical journals and continued medical education conferences utilize EBM through a strength-of-recommendation (SORT) process. The SORT gives grades for the effectiveness and quality of evidence to support the recommendation for treatment or therapy.[10] The volume of scientific research and medical journals is overwhelming. It was recently estimated that physicians would need 627.5 hours just to read the 7,287 journal articles that are published each month.[11] However, there are several web-based EBM tools available for physicians to quickly find the latest recommendations.[12]

Although EBM gives physicians solid scientific evidence on which to base their clinical decisions, it is not "cook-book" medicine. Even so, EBM does reduce the variation of the medical care delivered to patients across the country. Physicians fear that the "art of medicine" will be lost with the "science of medicine" provided by EBM. Physicians still must listen to the needs and values of their patients. Both the art and science of medicine can be balanced to achieve successful outcomes that provide cost-effective, quality health care.

EFFECTIVE EBM STRATEGIES TO LOWER HEALTH CARE COST

The diverse healthcare industry offers plenty of opportunities to lower the cost of medicine. EBM offers 3 cost-effective strategies to lower the overall cost of health care:

- Less costly or is cost-saving with an equal or better outcome, or
- More effective and more costly, with the added benefit worth the added cost, or
- Less effective and less costly, with the added benefit of the alternative not worth the added cost.[13]

The following paragraphs describe 5 key examples of how EBM can provide cost-effective health care with a reduction in overall cost.

Southeast Regional Medical Command (SERMC) Profit and Loss Reimbursement Model

SERMC has led the Army Medical Department (AMEDD) with an innovative Profit and Loss Reimbursement Model that rewards productivity and outcomes based on EBM with financial incentives. Results have shown improvement in clinical processes and outcomes through accurate care rendered, enhanced workload recorded, and care documented in the electronic medical record (EMR). The goals established by EBM for mammograms, pap smears, diabetic HbA1C and retinal exams, and asthma with controller medications have led to improved cost-

effective continuity of care and population health. In addition, SERMC hospitals are given financial incentives up to $6 million based on outcomes and performance productivity. This successful model will be incorporated throughout the AMEDD in FY07.

Disease Management Programs

The use of EBM with outpatient disease management programs has been extensive and has led to cost-effective health care. Smoking, obesity, and diabetes account for over 1 million deaths annually in the United States, and over $270 billion in direct and indirect medical costs.[14] Physician advocates leading multidisciplinary teams have implemented effective EBM programs targeting obesity, asthma, diabetes, hypertension, chronic pain, and high cholesterol. Results have shown reductions in hospital admissions and cost savings, and have documented a decrease in the progression of the respective diseases.

Leapfrog Group

The Leapfrog Group* identified 3 initial patient safety practices (leaps) accompanied by EBM to benefit patients and to provide cost-effective health care in the medical arena.[15] These 3 safety practices are EMR physician ordering, intensivist physician staffing (IPS) of intensive care units, and EBM hospital referrals. The results of EMR use showed a reduction in medical errors, adverse drug effects, length of stays (LOS), morbidity, mortality, and more cost-effective utilization of medication. If EMR were fully implemented, hospitals would save an estimated $1.5 billion annually. In addition, IPS initiatives would result in an annual savings of over 54,000 lives with an additional cost savings of nearly $16.5 billion. These savings were achieved through a decrease in LOS, productivity benefits through EBM, and lower error rates. Finally, EBM hospital referrals would save nearly $10 billion annually. All three of these measures incorporate EBM and lead to cost-effective and high quality medical care with great outcomes.

100K Lives Campaign

The 100K Lives Campaign† involves over 3,000 hospitals with the goal to avoid the nearly 100,000 annual deaths from medical injuries and 2 million hospital acquired infections.[16] It has been very successful in reducing deaths and morbidity. The campaign focuses on 6 EBM changes to avoid hospital deaths: rapid response teams, acute myocardial infarction care, prevent adverse drug events, prevent central line infections, prevent surgical site infections, and prevent ventilator-associated pneumonia. Additionally, these fully implemented initiatives will lead to a decrease in the 1% of US GDP that is spent on ICU medical care.[17]

Combination of EBM with EMR

The combination of EMR and EBM has shown promising results. Hieb stated that the benefit of this combination leads to improved reporting, cost-effective care, reduced medical errors, improved patient satisfaction, and competitive advantage.[18] This fusion has led to physicians developing case management protocols, decision support sets, provider order sets, and workflows that provide quality medical care. In addition, the high administrative cost of health care (26%) has been reduced. The Rand Corporation has shown that an implementation goal of having EMR in 90% of hospitals and doctors offices will require an annual cost of $8 billion for 15 years.[19] Furthermore, the combination with EBM will lead to annual efficiency savings of more than $77 billion after an accumulated benefit of $500 billion in 15 years.

IMPLICATIONS OF EBM AND RISING HEALTH CARE COSTS ON NATIONAL SECURITY

The United States spreads its influence, prosperity, and democracy throughout the world through its 4 instruments of national power—diplomacy, information, military, and economy (DIME). The military and economic components of the DIME are the 2 most important instruments to ensure both the national security and vital interests of the United States. Moreover, these 2 instruments are the most vulnerable to a healthcare system that is absorbing a bigger percentage of the GDP and federal budget. Currently, the government pays the bill for 60% of the overall healthcare cost in the US.[1] In the next 10 years, two major factors will affect the DIME and the cost of health care, the aging "baby boomer" population, and the rising cost of the Department of Defense (DoD) health care. These factors will have an enormous impact on our national security.

First, the aging baby boomer population of 77 million will lead Medicare and Medicaid growth from 25% of all healthcare spending in 1965 to 49% in 2014.[1] This

*Available at: http://www.leapfroggroup.org/home
†Available at: http://www.ihi.org/IHI/Programs/Campaign

will impose astounding costs for all taxpayers and the federal government. In order to pay the bill, the government will have to draw from other areas of the budget—education, infrastructure, and defense. Health care as a percentage of GDP in 1960 was 6%, as was defense and education.[6] In 2005, health care grew to 16% of the GDP while education remained at 6% and DoD dropped to 4%. Can Americans continue to absorb this rise in cost? Will they want to continue to pay for it in the years to come? Time and priorities will tell.

Finally, the impact of the cost of health care on DoD's budget is huge. DoD's TRICARE cost was $19 billion in 2001, grew to $37 billion in 2006, and is expected to top $64 billion in 2015.[20] In addition, health care represented 4.5% of DoD's budget in 1990 and is projected to increase to over 12% in 2015. This will have an impact on other DoD programs, eg, personnel, procurement, weapon systems, operations, and maintenance. The nation and DoD must make tough decisions in order to ensure that the strength of the instruments of national power are preserved. EBM provides an effective way to curb the rising cost of health care, and DoD has continued to lead the way in its implementation with EMR, as evidenced by the SERMC Profit and Loss Model.

POLICY RECOMMENDATIONS

In order to ensure the national security of the United States and to preserve its vital interest and enduring principles, 5 key policy recommendations are offered.

1. Develop and Assure Access to EBM

This policy is crucial to create nationwide standards of health care based on EBM with clear scientific evidence. This will ensure a reduction in the variance of healthcare and provide a common cost-effective process. In addition, create a central web portal that is developed by the respective professional medical societies and directed by the government. Practical clinical trials established by priorities from the government will lead to improvements of cost-effective medical care, quality of life, safety, and in the delivery of healthcare services.

2. Combine EBM with EMR

The multiple results from the SERMC Profit and Loss Model, disease management programs, Leapfrog Group, and the 100K Lives Campaign strongly support this recommendation. This is a force multiplier that provides safe, effective, quality health care with the addition of significant health care cost savings. This policy will ensure that multidisciplinary teams and physician champions create order sets, management tools, and outcome measurements which will lead to an overall reduction of medical errors. The investment by the US government and the healthcare industry will definitely pay off.

3. Ensure an Adequate Number of Primary Care "Gatekeepers"

These providers are the portal for entry of patients into the healthcare system. In combination with EBM, available gatekeepers have been shown to be the most cost-effective source of medical care. Patients are referred to specialists based on EBM criteria. This system works very well for Kaiser Permanente and countries with universal health care. The OECD studies have demonstrated that other western countries have better outcomes with a lower per capita spending on health care. This system must be tied into ensuring medical care for everyone in the United States, not just covering everything medicine has to offer. Furthermore, the primary care providers must emphasize and monitor EBM preventive medicine practices in the population. This will result in cumulative cost savings with a healthier population.

4. Align Incentives and Rewards for Improvement

Incentives are key to continued success and implementation of EBM into everyday practice. Outcome and utilization measurements must be aligned with documented results. This will lead to a limitation of procedures that are ineffective or marginally effective with resulting cost savings. Also, this can be extended to the patient population by rewarding good health practices (ideal body weight, no smoking, aerobic conditioning, etc) In addition, rewarding providers, hospitals, and healthcare organizations for building system improvements (EBM, EMR, etc) are keys for success.

5. Use the Government to Facilitate and Collaborate the Pursuit of the Other 4 Policies

The government has the "power of the payor," in that it pays 60% of the healthcare costs in the

United States. Accordingly, it can direct change in the system with financial incentives and processes. The government can subsidize research and development of the systems and dissemination of the information, and establish practice standards and priorities with an implementation timeline. Also, it can institute tax policy changes that make health care more affordable by shaping and supporting the market. This can be achieved through insurance subsidies, expansion of the health savings and flexible savings accounts, decreasing administrative bureaucracy, and increasing patient cost sharing. The government must promote the education of healthcare consumers on preventive, self-care, and cost-effective health care. Finally, it must promote the synergy of public and private sectors and build upon the gains and foundation of EBM.

Incorporation of all 5 of the recommended policies will ensure success for the patient, the healthcare industry, and the government.

CONCLUSION

As the strategy of EBM becomes more incorporated in everyday practice, the better the outcomes are for patients and the lower the healthcare costs are for the nation. In addition, EBM has consistently shown improvements in patient safety, quality of life, and in the deliverance of cost-effective health care. These improvements are essential to maintaining the national security and to protecting the vital interests of the United States through the DIME instruments of national power. Consequently, implementation of the 5 policy recommendations for EBM will ensure that the enduring principles of the United States—Life, Liberty, and the Pursuit of Happiness—are preserved for all Americans.

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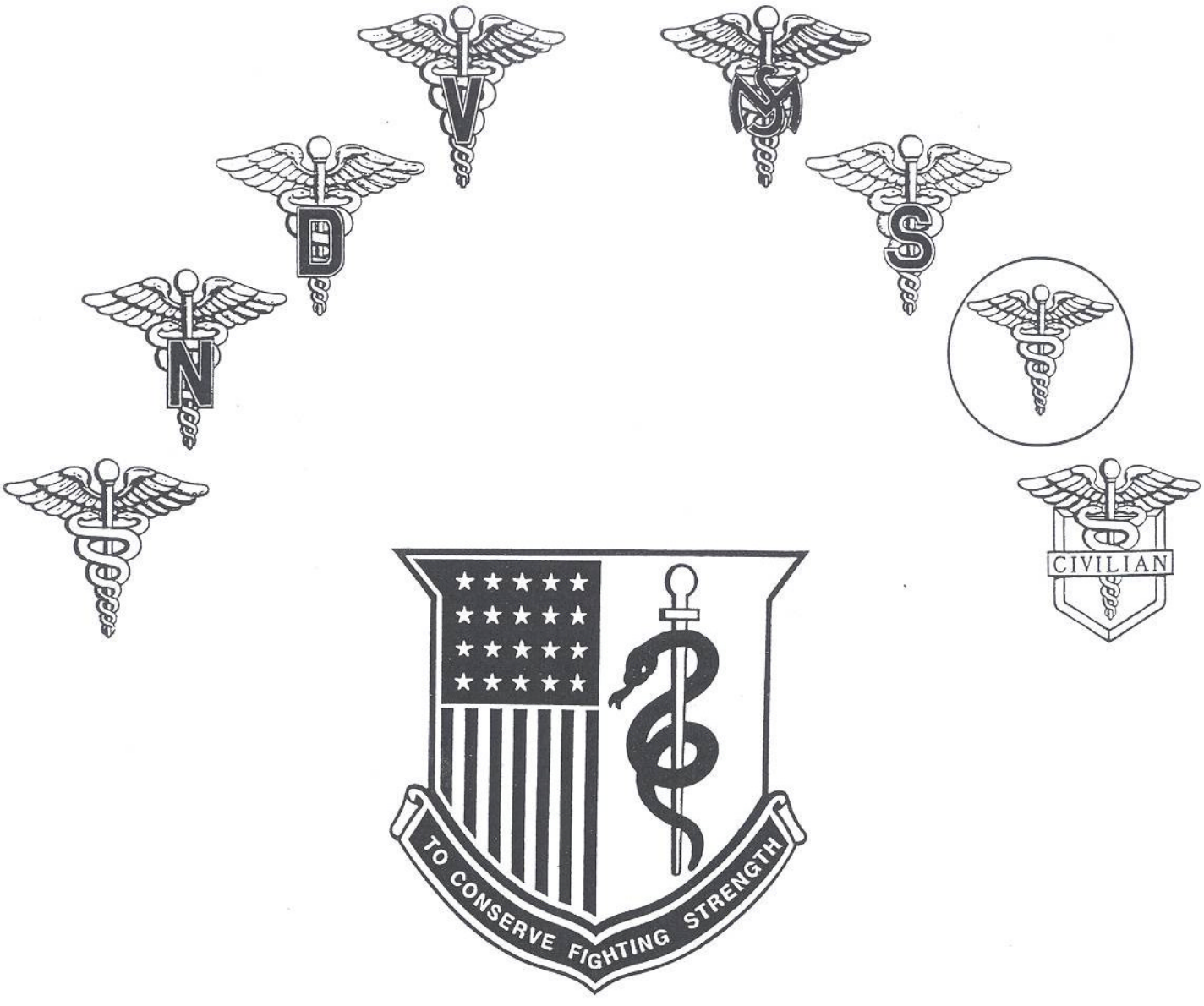

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