SPECIAL REPORT

Military–Civilian Collaboration in Trauma Care and the Senior Visiting Surgeon Program

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On June 14, 2006, the Institute of Medicine released a three-part report on the future of emergency care, underscoring the evolving crisis in access to urgent medical care in the United States.[1] The clear threat of future terrorist activity and recent experience with natural disasters highlight the need to develop a comprehensive response system based on the integration of civilian and military resources.[2-5] Collaboration between civilian and military surgeons during times of war is evident throughout our history, and civilian surgeons have provided surgical care to the wounded since the Revolutionary War. Many observations during times of intense conflict translated into advances in civilian medicine.[6,7] Critical analysis by military and civilian sources after the first Gulf War (1991) brought about several fundamental changes in the operation and structure of military medical units.[8,9] A 1998 General Accounting Office report identified the lack of valid training in trauma care for military medical personnel, who practiced largely in military treatment facilities caring primarily for healthy, active-duty personnel and their dependents or retirees.[10-12] The report recommended the development of collaborative military and civilian training platforms at urban level 1 trauma centers.

In response to this mandate, the Joint Trauma Training Center was established at Ben Taub General Hospital in Houston in 1999 for military trauma teams,[13-16] and the Department of Defense subsequently opened six additional trauma training sites. These programs have exposed military surgeons to cutting-edge civilian concepts in trauma care (including damage-control surgery, the use of recombinant activated factor VII [rFVIIa], and the trauma-systems approach to care). In addition, these programs have facilitated a dialogue between military and civilian trauma surgeons and are helping to improve clinical outcomes in the ongoing wars in Iraq and Afghanistan.[17,18]

The Senior Visiting Surgeon Program has been developed and implemented by the American Association for the Surgery of Trauma in conjunction with the American College of Surgeons Committee on Trauma (ACS-COT). The global objective of this program is to establish scientific exchange during 2-to-4-week tours at the Landstuhl Regional Medical Center in Landstuhl, Germany, between the leaders in civilian trauma care in the United States and experienced military clinicians. This program allows civilian trauma surgeons to participate in the care of injured soldiers by performing surgical procedures and directing intensive care; they also contribute to education at the center through lectures, serve as scientific mentors, and provide expert commentary during performance-improvement activities.

LANDSTUHL REGIONAL MEDICAL CENTER

The Landstuhl trauma center is unlike any trauma center in the United States. The medical staff is charged with providing care for critically injured soldiers who have already undergone initial resuscitation and operative care in either Iraq or Afghanistan and who will be transported to a military facility in the United States (e.g., Walter Reed Army Medical Center, the National Naval Medical Center, or Brooke Army Medical Center) as soon as their condition permits. In the current conflict, the typical soldier has been injured by an improvised explosive device (IED), often while riding in a Humvee, resulting in a combination of blunt and penetrating injuries and burns. The patient receives first aid from a medic and is then transported by helicopter to trauma facilities in the combat zone, where abbreviated opera-

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tions (damage control surgery) typically include packing the abdomen for hemorrhage control, stapling bowel injuries, placing a vascular shunt across injured vessels, and providing temporary external fixation of fractures.[19-21] Within a few hours of injury, the patient is transported by helicopter to the next level of care (at Baghdad or Balad in Iraq and at Bagram in Afghanistan), where more definitive surgery includes removal of abdominal packing, bowel anastomoses, formal revascularization procedures, fasciotomies, escharotomies, burn débridements, and washout of open fractures. These severely injured patients are then transported by the Air Force's Critical Care Air Transport Teams in large, fixed-winged planes to Landstuhl, where they typically arrive within 24 to 36 hours of their injury.[22]

For the past 6 years, Landstuhl has functioned as the central clearing site for all patients evacuated from Iraq and Afghanistan, now exceeding 18,000 injured patients and 2500 intensive care unit (ICU) admissions. The receiving teams at the trauma center get 8 hours' notice of incoming patients and often receive many critically injured patients at the same time, a scenario that is similar to that of a multiple-casualty event in a U.S. trauma center but that occurs several times per week at Landstuhl. Using the Web-based Joint Patient Tracking Application, the teams can review each patient's case (including injuries sustained, operations performed, blood products received, and medications administered) before the patient arrives. Computed tomographic scans and the results of other radiographic assessments are also available on this Web-based registry.

A major focus of the multidisciplinary critical care team is the delivery of state-of-the-art intensive care. Critically injured patients are transported directly from the nearby Ramstein Air Base (also in Germany) to the Landstuhl ICU, where the goal is to continue the resuscitation process, identify all injuries, reassess, débride, wash out major wounds, and prepare the soliders for transport back to the United States as soon as possible. A fully integrated ICU team of surgeons, pulmonologists, respiratory therapists, nurses, and a dedicated pharmacist work together efficiently and effectively in this time-sensitive and complex environment. There is a refreshing disregard of service branch, rank, and specialty.

Antibiotic use and infection control are closely monitored by an infectious disease physician who attends daily ICU rounds. Severe infections include acinetobacter, which is often multidrug resistant.[23] Feeding tubes are placed endoscopically so that nutritional support will not be interrupted for repeated operative procedures or during transport. Social workers and other support staff make sure that families in the United States are continually apprised of a soldier's condition and any plans for transport. Rapid evacuation from the combat zone, injury evolution, and obligatory fluid resuscitation often necessitate fasciotomies or escharotomies. Rhabdomyolysis and renal dysfunction are predictably more common in these wounded soldiers than in civilian trauma patients, requiring careful monitoring of serum creatine kinase and potassium levels as well as acid–base balance.[24] Burn teams from Brooke Army Medical Center in Texas fly to Germany to assist in the early management of major burns and to accompany patients back to their hospital to facilitate continuity of care.[25]

Each of the Air Force's Critical Care Air Transport Teams is able to care for up to three intubated patients or a total of six critically injured patients. Each such team consists of a critical care physician, an ICU-qualified nurse, and a respiratory therapist, plus the equipment needed to continue ICU care for several hours. On one trip to the United States (observed by Dr. Knudson) the C-17 cargo plane carried a total of 51 patients, including 2 intubated patients. In addition to a ventilator, each critically injured patient had automated blood pressure, pulse, oxygen saturation, and exhaled carbon dioxide monitors, as well as infusion pumps. The transport team was joined by several other aeromedical evacuation teams consisting of nurses and technicians who cared for those who were less severely injured. During the flight, the respiratory therapist adjusted ventilator settings as needed, on the basis of point-of-care blood gas results, and a physician monitored serum electrolytes, glucose, and hematocrit values. Sedatives and narcotics were administered continuously to the intubated patients, and nurses were prompt in responding to pain medication needs. Nutrition was provided for all patients, including continuous tube feeding for those requiring mechanical ventilatory support. The plane was noisy, and the flashing lights of the alarm system were seen rather than heard. Despite these challenges, this specialized "ICU in the air" was highly effective and undoubtedly

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has contributed to the low rate of death among soldiers wounded during the current conflict.[18]

The trauma service at Landstuhl has morbidity and mortality and multidisciplinary peer review conferences in accordance with trauma center requirements of the American College of Surgeons.[26] In a weekly trauma clinical video teleconference, the chief of trauma at Landstuhl conducts a systemwide review of wounded soldiers through real-time interactions with deployed units in Iraq and Afghanistan as well as with the receiving facilities in the United States. Surgeons in the combat zone begin with a description of the initial management of the patients, physicians at Landstuhl follow with descriptions of the patients' continued care, and the physicians at U.S. sites provide outcome details. This unique conference, linking care that spans three continents, provides timely feedback for all involved and is an important educational as well as a performance-improvement tool.

PARTICIPATION OF THE SENIOR VISITING SURGEONS

In addition to assisting in daily surgical and ICU care, the visiting surgeons provide other services, depending on their areas of interest and expertise. During the authors' visit, formal grand rounds lectures delivered by participating surgeons gave deployed staff the opportunity to learn about new management strategies and obtain required credits for continuing medical education. A lecture and demonstration of a technique for pre-peritoneal pelvic packing to control life-threatening hemorrhage from major pelvic fractures (delivered by Dr. Moore) served as the introduction of this treatment option for combat care.[27] Because of the high turnover of the deployed nurses and physicians working in this challenging environment, there was a need to develop standardized treatment guidelines, a task pursued by several of the visiting surgeons. Particularly suitable were the ICU protocols generated by the National Institutes of Health through the research program called Inflammation and the Host Response to Injury.[28] Enhancement of prevention measures, specifically in providing protection from eye injuries during combat, was the goal of another visiting surgeon, whereas another focused on the emergency department at Landstuhl to make sure that equipment met trauma-center standards.

A common problem in these injured soldiers, identified 3 years ago through the hospital's performance improvement process, is the development of venous thromboembolic events. The association between these events and acute injury has been well described in civilian settings, and in trauma patients pulmonary embolism remains a major preventable cause of death.[29,30] In addition to post-traumatic risk factors, the prolonged air travel imposed on these injured troops may contribute to venous thromboembolic events, although recent data in patients with burns suggest otherwise.[31,32] To address concerns about these events in combat casualties, a prospective study will use the resources at an injury research center in San Francisco sponsored by the Centers for Disease Control and Prevention.

Faced with the devastating injuries caused by IEDs, military surgeons have developed aggressive guidelines to preempt or reverse coagulopathy in patients requiring massive transfusions. These guidelines fall under the term damage control resuscitation and include the use of thawed plasma in a 1:1 ratio with red cells, fresh whole blood, and rFVIIa.[33] Although rFVIIa was originally developed for the treatment of patients with hemophilia with inhibitors to factor VIII or IX, it is used in virtually all level 1 U.S. trauma centers as part of a massive transfusion protocol. The administration of rFVIIa has been associated with thrombosis, although in the only prospective trauma trial to date, there was no significant difference in the rate of clinical thrombosis between those who received rFVIIa and those who did not (2% and 3%, respectively, in blunt trauma and 4% and 3%, respectively, in penetrating trauma).[34] In January 2007, the Department of Defense presented to Congress its review of data focused on the use of rFVIIa in patients with combat trauma. Published combat injury data at that time showed a 20% reduction in red blood cell transfusions in the group receiving rFVIIa, with equal rates of thrombotic events.[35] Also reviewed in detail were data from 2004 through 2006 on 615 soldiers severely injured in combat, compiled from the Joint Theater Trauma Registry. Although satisfied with the presentation, congressional committees requested a further objective, unbiased expert review. A panel from the Senior Visiting Surgeon Program reviewed the data and issued a report concluding that rFVIIa was being used appropriately by the

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military physicians; this input was reassuring to Congress.

Perhaps the greatest measurable effect the Senior Visiting Surgeon Program has had on the quality of trauma care in military hospitals stems from the recent site visit undertaken by the Verification Committee of the ACS-COT at Landstuhl, which was the first such visit conducted outside the United States and the first for a military hospital. The visiting team of surgeons spent 2 full days at Landstuhl and did not find a single deficiency that would prevent the hospital from meeting the criteria necessary for verification as a major trauma center. Other military hospitals are now asking for consultation visits in preparation for obtaining verified trauma-center status. This recognition can help assure injured soldiers and their families that the highest level of trauma care is being delivered within the military trauma system.

For those of us who have not served in the military, the Senior Visiting Surgeon Program offers a privileged opportunity to participate in the care of our injured soldiers and to facilitate the introduction of the most recent advances in trauma and critical care to the battlefield. We are hopeful that the program will be expanded to offer civilian trauma surgeons additional opportunities to participate in surgical care in combat regions. Other professional surgical groups (orthopedics and neurosurgery) have examined our program and are implementing similar exchanges with the military.

INTEGRATING CIVILIAN AND MILITARY RESOURCES FOR DISASTER RESPONSE

In the event that terrorist activities occur on U.S. soil, we remain largely unprepared for their most common form: conventional explosive events.[2-5,22,36] The car bombs found in London in June, reports from Homeland Security, and threats against the planned Democratic National Convention in Denver are sobering alarms. Terrorist events can involve large numbers of casualties, and the resulting injuries will resemble those being managed every day in Iraq and Afghanistan.[3,37] Although a few visiting physicians and surgeons have now encountered these unique injuries, further collaborative efforts are urgently needed. The approximately 800 trauma and burn centers in the United States must be the backbone of our nation's trauma response system for any large-scale terrorist event.[38,39] By combining the casualty care and trauma systems expertise of the U.S. military with the existing expertise at civilian trauma and burn centers, we can improve the care of all injured patients in our country, regardless of whether the injuries are caused by everyday traumatic events such as motor-vehicle crashes, by natural disaster, or by terrorist attack.

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