INTO THE THEATER:

Perspectives from a civilian trauma surgeon's visit to the Combat Support Hospital in Balad, Iraq

by M. Margaret Knudson, MD, FACS

The history of trauma parallels the history of war, and there is no doubt that many of the principles that guide trauma care are being rewritten during the ongoing global war on terrorism currently being waged in Iraq and Afghanistan. In fact, this conflict has the lowest overall case fatality rate of any war in U.S. history. This outcome is truly remarkable, considering that the care given to these wounded troops spans three different continents. In order to better appreciate these advances in military medicine, the leadership of the American College of Surgeons Committee on Trauma (COT) and of the American Association for the Surgery of Trauma, working in conjunction with the U.S. military, developed the Senior Visiting Surgeons (SVS) program.

The global objective of this program is to establish scientific exchange between the leaders in civilian trauma care and our experienced military counterparts. The SVS program is also meant to rapidly forward the lessons learned in the military realm to the civilian sector. To date, the SVS efforts have been centered at the largest U.S. military medical center outside of the country's borders: Landstuhl Regional Medical Center (LRMC) in Landstuhl, Germany. LRMC is the receiving hospital for all injured troops being evacuated from Iraq and Afghanistan and the last stop for these patients before transfer back to the U.S.

The SVS program, which was initiated in 2006, involves a two- to four-week rotation at LRMC as part of participants' trauma/critical care service. The civilian surgeons rotating at LRMC have provided scientific seminars, given surgical grand rounds, instigated or mentored scientific research, assisted in preparing for trauma center verification, attended the peer review conferences (which also span three continents), and, most importantly, were privileged to participate in the surgical and critical care being rendered to these wounded troops. Every SVS has described this care as being outstanding.

The medical personnel at LRMC—consisting of members of the U.S. Army, Navy, and Air Force—face challenges unlike those at any other trauma center. First, the injuries being inflicted on our troops are complex and of extremely high acuity. The typical injury pattern follows an explosion and may consist of blast, burn, blunt, and penetrating injuries combined. Not uncommonly, the injured troop has undergone one or two operative procedures before arriving in Germany, including vascular shunting followed by definitive vascular repair, damage control laparotomies, decompressive craniotomies, and stabilization of fractures or the initial phase of fluid resuscitation for burn wounds. Most of these patients leave the combat theater hospital within 24 to 48 hours of their injury, flying eight hours to land at Ramstein Air Force Base in Germany, a short distance from LRMC. The patients arrive together in busloads and are triaged to either surgical wards or the intensive care unit. It is not uncommon to receive five to seven critically injured patients simultaneously at LRMC. Fortunately, via the Web-based Joint Patient Tracking Application, the data on these patients (including operative notes, computed tomography [CT] scans, and so on) can be reviewed long before their arrival.

Once in Germany, the wounded troops undergo a reevaluation of all injuries. Invasive lines are changed and laboratory values rechecked, and many undergo additional surgical procedures such as closure of abdominal wounds, burn or soft tissue wound debridements, muscle compartment releases if needed, and more definitive treatment of fractures. Scanning for deep venous thrombosis (or pulmonary emboli) is a high priority. Steps are taken to identify and control infections and emphasis is placed on the provision of adequate nutrition. Anxious families are contacted and updated as to the condition of their loved ones arriving in Germany. All of these activities are done on a strict timeline, with the goal of transporting stabilized patients to the continental U.S.—to Walter Reed Army Medical Center; National Naval Medical Center in Bethesda, MD; or Brooke Army Medical Center in San Antonio, TX—as soon as feasible (typically 24 to 48 hours later). As this next phase of transport involves

Opposite, top photo: Helicopter landing outside the emergency department, bringing injured patients.

Center: "Heroes Highway" (left to right): Joshua Alley, MD; Col. Jay Johannigman, MD, FACS; Colonel Jenkins; Dr. Knudson; Todd Rasmussen, MD, FACS; and Carl Baker, MD.

Bottom: Dr. Knudson participating in side-by-side craniotomies in the operating room of the 332nd.

at least 12 hours in flight (18 hours to Brooke), there is no room for error, and adequate preparation of each patient before transport is a dictum. Every laboratory value, line, tube, and monitor must be corrected, secured, and accurate before leaving LRMC.

Despite all of these challenges, the remarkable care rendered at LRMC is delivered with the highest professionalism and with the deepest compassion. Indeed, this was reaffirmed by members of the ACS/COT Verification Review Committee who recently verified that LRMC met (and often exceeded) all of the criteria for a level II trauma center as defined by the COT.* (The observations of some of the SVSs while at Landstuhl have been published in two peer-reviewed articles†). Following the lead of the SVS program, civilian neurosurgeons, orthopaedic surgeons, and vascular surgeons have also volunteered their services at LRMC.

Although the experience at Landstuhl was both educational and fulfilling for the civilian surgeons, many of us felt that we were missing the "front end" of care being delivered in the combat zone. We wanted to understand more fully the challenges of working in combat support hospitals and gain experience in the initial treatment of these often devastating injuries. I was recently offered the incredible opportunity to visit the Air Force's 332nd Air Expeditionary Wing (AEW) Theater Hospital located at Balad Air Base in Iraq. While I prepared for this adventure, I formulated the following list of my objectives for taking this step:

1. To assist in codifying the important trauma surgical lessons learned during the current conflict in order to preserve them for future conflicts
2. To identify areas that might benefit from collaborative research involving both military and civilian trauma research groups
3. To provide consultation for the continued development of the military trauma system
4. To foster the educational process needed to translate the lessons learned in Operation Iraqi Freedom and Operation Enduring Freedom to civilian trauma care both for daily use and in preparation for mass casualties and disasters
5. To explore the potential development of programs whereby civilian trauma surgeons might provide assistance to our military surgical colleagues

2008 Joint Theater Conference

One of the initial goals of our mission to Iraq was to participate in the Joint Theater Trauma System [JTTS] Chief Conference, The Continuum of Trauma Care in the Matured U.S. Central Command/European Command Areas of Responsibility. I was honored to be accompanied on the entire trip by Col. Donald Jenkins (USAF), MD, FACS, who met me in Germany, assured that I got through all checkpoints en route to Iraq, and attended to my security at every level. We were both invited to present at

Recent publications describing military treatment modalities

- Chung KK, Blackbourne LH, Wolf SB, et al. Evolution of burn resuscitation in Operation Iraqi Freedom. *J Burn Care Res.* 2006;27:606-611.
- Schreiber MA, Perkins J, Kiraly L, et al. Early predictors of massive transfusion in combat casualties. *J Am Coll Surg.* 2007;205:541-545.
- Spinella PC, Perkins JG, McLaughlin DF, et al. The effect of recombinant activated factor VII on mortality in combat-related casualties with severe trauma and massive transfusion. *J Trauma.* 2008;64:286-294.
- Holcomb JB. Damage control resuscitation. *J Trauma.* 2007;62:S36-S37.
- Rasmussen TE, Clouse WD, Peck MA, et al. Development and implementation of endovascular capabilities in wartime. *J Trauma.* 2008;64:1169-1176.
- Holcomb JB, Champion HR, Pruitt BA, et al. Advances in combat casualty care: Clinical outcomes from the way. *J Trauma.* 2008;64(suppl):S1-S205.

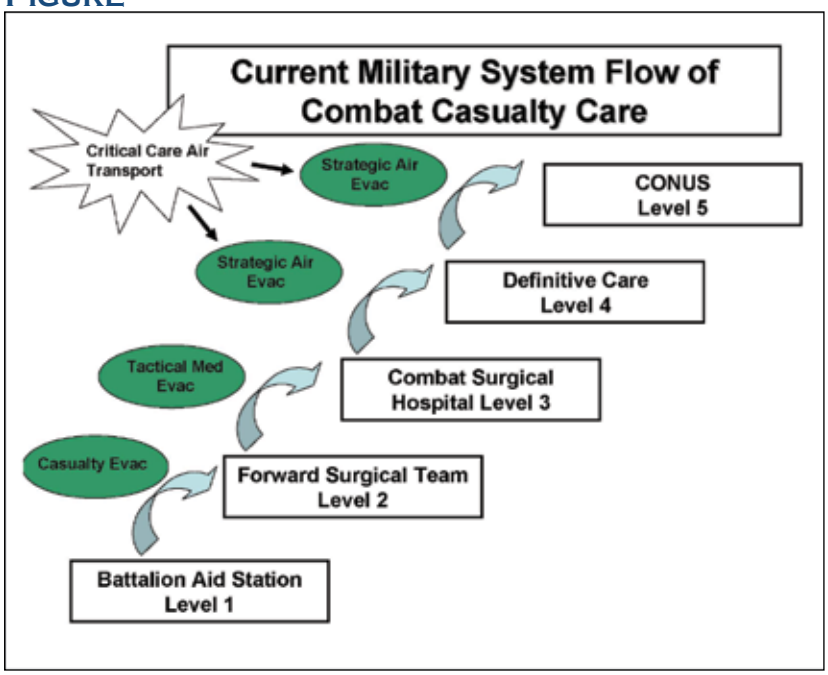
*Knudson MM, Mitchell FL, Johannigman JA. First trauma verification review committee site visit outside the U.S.: Landsthul Regional Medical Center, Germany. *Bull Am Coll Surg.* 2007;92:16-19.

†Moore EE, Knudson MM, Schwab CW, Trunkey DD, Johannigman JJ, Holcomb JB: Military-civilian collaboration in trauma care and the senior visiting surgeon program. *New Engl J Med.* 2007;357:2723-2727; and Trunkey DD, Johannigman JA, Holbomb JB. Lessons relearned. *Arch Surg.* 2008;143:112-114.

this inaugural trauma conference, facilitated by Col. George Costanzo (USAF), who was at that time serving as the director of the JTTS. Surgeons from the various echelons of care, from far forward surgical units to the combat support hospitals throughout Iraq, attended the conference and presented their experience in treating various injuries and the challenges of dealing with the ebb and flow of patient care demands. The formal educational portion of the conference highlighted some of the developments in combat casualty care that are clearly contributing to the low fatality rate in this war. Although a discussion of these treatment modalities is beyond the scope of this article, they are well described in recent publications (see boxed item, page 18) and can be summarized as follows:

- Renewed use and redesign of tourniquets that can be self-applied
- Use of innovative hemostatic dressings for open wounds
- Adoption of a massive transfusion protocol that advocates for more liberal use of freshly frozen plasma and platelets along with packed red cells (so-called damage control resuscitation)
- Use of point-of-care thromboelastogram results to guide transfusion practice
- Recognition of the advantages of using fresh whole blood
- Use of the procoagulant-activated factor VII early in patients requiring massive transfusions
- Aggressive use of vascular shunts for temporary control of vascular injuries
- Development of endovascular capabilities in combat support hospitals
- Guidance of burn resuscitation using a standardized clinical practice guideline algorithm that travels with the patient
- Adoption of damage control strategies for abdominal, vascular, and orthopaedic injuries
- Screening for symptoms of minimal brain injury in all injured troops
- Redesign of personal protective gear

Figure



The JTTS

Care of the injured in Iraq and Afghanistan begins at the site of wounding with self-aid and buddy care. Further care in the field may be rendered by the combat medic as dictated by the guidelines promulgated by the Committee for Tactical Combat Casualty Care. When appropriate, or if nearby, the casualty may be moved to a forward operating base and the battalion aid station (Level II), where field medics initiate additional first aid for the wounded. Forward surgical teams are located in many locations throughout the theater and are designated as level IIB facilities, capable of conducting life and limb stabilization in far-forward and austere conditions. The patient is then transferred via helicopter to the combat surgical support hospitals (Balad and Baghdad in Iraq). These facilities are designated as level III facilities and

have more complete surgical teams, including surgical specialists and intensive care unit (ICU) facilities. The current level III centers in the theater may be roughly equated as civilian level II trauma centers in the U.S. The surgical care at the combat support hospitals is intended to be more definitive. Following stabilization within the theater, the patients are evacuated to the level IV facility at LRMC via the Air Force aeromedical evacuation system. The level V facilities are the military trauma receiving hospitals in the U.S (see Figure, page 19).

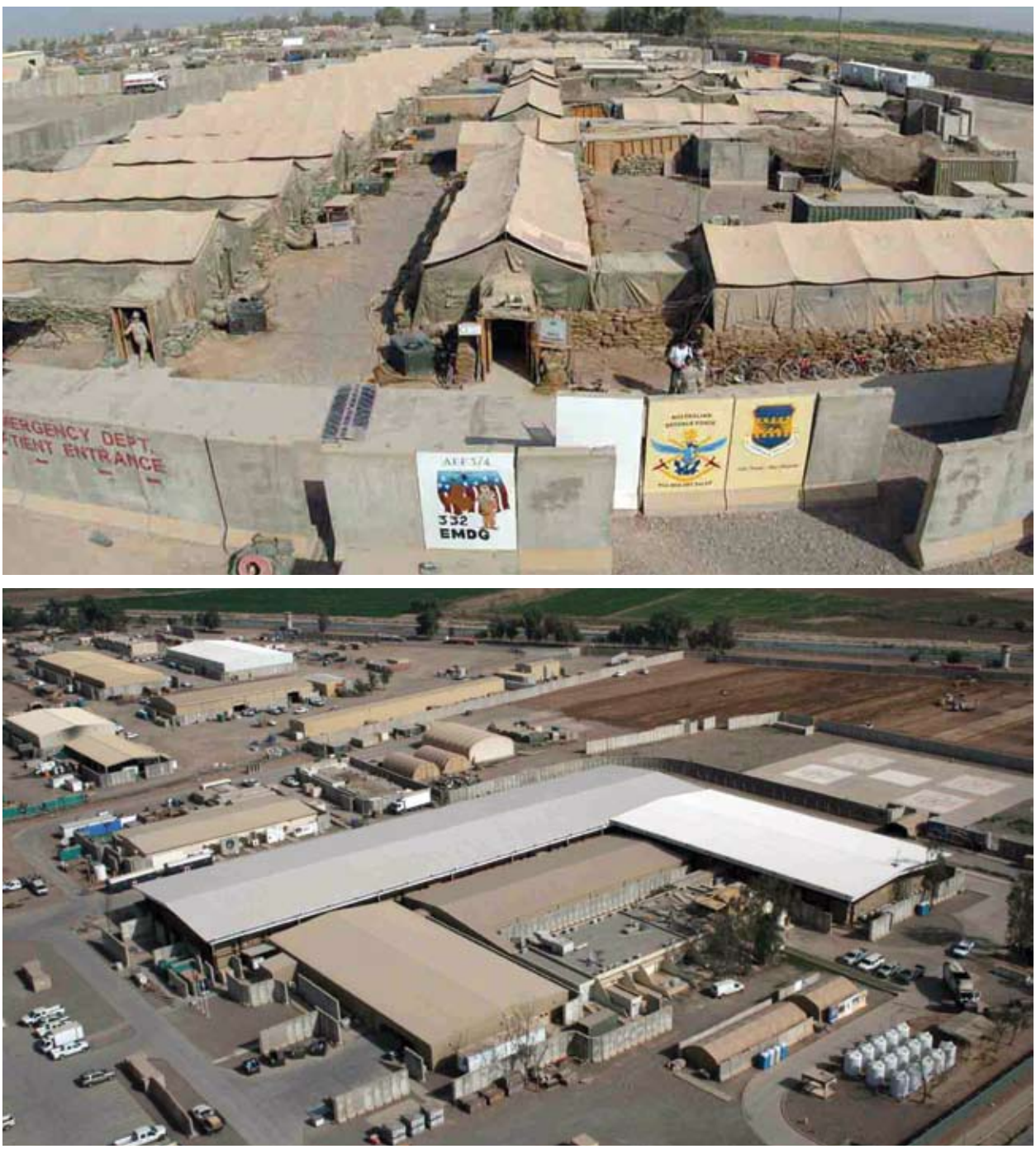
This complex trauma system is coordinated by a number of measures. Leadership is provided by the JTTS director, who oversees all echelons of care throughout Iraq and Afghanistan. The second important component is the joint patient tracking application, the Web-based system allowing entry of patient data at each level of care. There are also trauma program managers at various locations in the theater system who supply the initial entries into the joint theater trauma registry, a robust trauma database that now contains data on several thousand injured troops and into which data are entered at each level of care. Research personnel have also been deployed into theater hospitals. The very timely performance improvement process is facilitated by the weekly clinical video teleconference, which connects the military medical units in Iraq and Afghanistan by audio to LRMC and Walter Reed and to the U.S. Army facilities in San Antonio (audio and visual) during which individual patients are discussed and their care reviewed at every level. This coordinated process has also resulted in the development of a number of trauma clinical practice guidelines that are considered standards of care within the theater trauma system, including prophylaxis for venous thromboembolic complications, antibiotic use, prevention of hypothermia, and the management of specific injuries such as burns, vascular trauma, and traumatic brain injuries.[‡] This highly functional trauma system is truly remarkable when one considers that it was largely developed and refined *during* the war.

[‡]Eastridge BJ, Jenkins D, Flaherty S, et al. Trauma system development in a theater of war: Experiences from Operation Iraqi Freedom and Operation Enduring Freedom. *J Trauma.* 2006;61:1366-1373.

The trauma experience at Balad

During the second part of my visit, I was able to integrate myself into the surgical team and participate as much as possible in patient care and in the operating room at the 332nd AEW hospital. This hospital serves not only as a level III combat support facility but also as the primary collection point for casualties requiring evacuation out of theater. The initial configuration of the hospital consisted of more than 30 interlinked tents, but in 2007, the 332nd moved into a new fixed facility (see photos, page 21). The hospital consists of an emergency department, four operating rooms, an ICU, and a large surgical ward (see photos, pages 22-23). There are also limited outpatient facilities, a well-stocked blood blank, advanced imaging capabilities, and a clinical laboratory. The majority of patients arrive by helicopters that land just outside the emergency department. From the desk in the emergency department, one can stand and see the entire room and observe all activities, which is an advantage during mass causality situations. The week before my arrival, the hospital received 32 casualties during the course of 90 minutes, victims of a suicide bomber in a market. The teams divide themselves efficiently among the casualties, blood and plasma is delivered promptly, laboratory results are back within minutes, and ultrasound units for FAST (Focused Assessment by Sonography in Trauma) exams are readily available. There are two multidetector CT scanners just off the main room and immediately available, as is the radiologist.

The surgical team at the time of my visit consisted of eight general surgeons (two of whom were also vascular surgeons and two trained thoracic surgeons), two orthopaedic surgeons, two oral-maxillofacial surgeons, two neurosurgeons, one ear-nose-throat surgeon, one urologist, and two ophthalmologists. The team is supplemented by emergency physicians, internists, physician assistants, nurses, and anesthesiologists. There are four operating rooms that are fully staffed seven days a week. A "normal" daily schedule consists of somewhere between 12 to 15 semi-elective cases on patients already in the hospital; however, rooms are always ready to provide immediate care to the incoming injured and it



The original 332nd as a series of tents (top), and the newer hospital with Kevlar protective roof over a solid structure.

Entrance to the emergency department at the 332nd.

is not unusual to have two patients being operated upon simultaneously in the same operating room theater.

The ICU is an open unit with beds separated only by curtains. Most of the patients in the ICU are host nationals (Iraqi civilians, Iraqi military, contractors, and so on). The U.S. troops are evacuated to LRMC in Germany usually within 24 hours of their arrival if their condition permits (see photo, page 24). This open ICU presents multiple challenges, including the need to meet the care of men, women, and children alike. The difficulties in maintaining precautions against nosocomial infections are evident when walking through such a busy facility located in the middle of an austere and warm environment. An additional clinical challenge is the state of malnourishment of many Iraqi patients, affecting their ability to heal these large, high-energy combat wounds. Provision of total parenteral nutrition is limited by severe infectious complications and the use of enteral nutrition is often limited by open abdomens, enteric fistulae, or intra-abdominal infections. An additional challenge faced by the military medics is the provision of ongoing care for the patients who are Iraqi nationals. The current state of the medical care in Iraq is very austere and limited even in the most rudimentary components of health care. This became most apparent in the process of discharge planning, as the military medics attempted to return their Iraqi patients into a health care system vastly different than the standards most U.S. physicians are accustomed

The emergency department at the 332nd.

to. Sadly, the media have directed little attention to the humanitarian side of the mission in the Middle East, especially by our deployed medical personnel.

On my first day on-call, we received several civilians injured by gunfire. Two were very young children who had sustained gunshot wounds to the head. They were examined, intubated, and had lines established and CT scans performed (and read by the radiologist and the neurosurgeons), and both children were taken to the operating room where two craniotomies were initiated side by side by two neurosurgeons within 20 minutes of arrival. Most U.S. trauma centers would find this scenario very difficult to replicate.

During my short stay in Balad, in addition to a craniotomy, I participated in several wound debridements, abdominal reexplorations, fasciotomies, vascular repairs, amputations, and a thoracotomy. The wounds encountered in this combat environment are significantly different than those common in civilian trauma care. The majority of injuries are related to either high-energy missile wounds (AK-17, M-16) or to blast injuries (improvised explosive device, mortar rounds, explosive formed projectiles, and so on). The extent and scope of injuries normally include multiple sites, soft tissue as well as orthopaedic injuries, often with concomitant vascular compromise. The appropriate trauma evaluation of these patients includes a thorough examination of all areas of the body and must take into consideration both blunt and penetrating mechanisms of force transmission. The variety and the size of objects removed from wounds as the result of explosive devices are unlike anything seen in our country.

My last day at the 332nd was the hardest. A U.S. soldier was brought in with four tourniquets in place after a devastating explosive injury. He was in profound shock and taken directly to the operating room where four surgical teams assembled around his four limbs as well as his neck, where he had an obvious penetrating injury. Unfortunately, the patient expired (one of the few deaths in this operating room, which is remarkable in itself). Nearly the entire hospital staff immediately assembled for prayers and for the draping of the American flag over his body (Patriot's Detail). That night, all the surgeons involved in this case met in the "lounge" on the rooftop of the hospital (affectionately referred to as "OR #5") and discussed the case and what

The flight line where injured patients are loaded for transport to Germany.

might have been done differently. This was truly a unique mortality conference and, taken together with the weekly video-teleconference described previously in this article, can serve as an excellent model for civilian trauma centers.

CCATTs: Critical care in the air

Another unique experience was my ability to observe the transport of injured troops from Iraq to Landstuhl and then from Landstuhl to Andrews Air Base under the care of the Air Force Critical Care Air Transport Teams (CCATT). The transport of critically ill patients and all the needed equipment—including ventilators, pumps, medications, nutrition, monitors, and so forth—is an art in itself, and loading it all into the back of these huge cargo planes without incident in the dark of night in the middle of the desert is like a well-orchestrated dance. Patients with less severe injuries (typically heading for ward care at LRMC or Walter Reed) are loaded first, to be attended by nurses and medical technicians. (These planes can transport as many as 50 patients at a time.) The back of the plane is reserved for the intensive care patients, each of whom has his or her own CCATT team. Each team consists of a critical care physician (surgeon, emergency physician, anesthesiologist, cardiologist, and so on), an ICU-qualified nurse, and a respiratory therapist. During the flight, blood gases are monitored, as are electrolytes using point-of-care technology; nutritional support is continued; and narcotics and sedatives are administered as needed. The plane is cold and noisy, and the monitor alarms must be visible because they cannot be heard above the background noise of the jet engines. Despite these challenges, this ICU in the air is highly effective and has provided safe transport for stabilized (though not necessarily stable) critically injured troops with the goal of getting them back to the U.S. as soon as possible. It serves as an excellent model of an evacuation process that might be used during a natural or man-made disaster.

Directives for ACS Fellows

For the Fellows of the American College of Surgeons who are not current members of the military, what can we do to provide support and

assistance to our deployed military colleagues? I would submit the following directives:

1. We need to critically and scientifically evaluate the lessons learned by the military surgeons during this conflict and be cognizant of situations where we can apply them in civilian trauma care.
2. As many of the senior military surgeons will be separated from their respective military posts before the next conflict, we must assist them in developing a "repository" for these important lessons, so that they can be passed on to the next generation of military medics.
3. We should continue to work with the military toward the goal of developing a worldwide military trauma system, using the ACS COT Verification and Systems Consultation Committees.
4. We should consider innovative programs that would allow civilian surgeons to fill posts now occupied by military physicians. For example, civilian surgeons could work at Veterans Affairs Hospitals, military hospitals in the U.S., or (after proper training) fly CCATT missions from LRMC to Andrews in order to relieve our military colleagues. Perhaps these nondeployable positions could be filled by recent graduates of surgical and specialty residency programs as a method of paying back medical school debt.
5. Finally, we have an obligation to assist in the humanitarian medical efforts in a stabilized Middle East.

Honor and privilege

It has been a distinct honor and a privilege for me to have been given such an up-close and personal view of this highly organized and successful trauma care system put in place by the U.S. military. For those readers who have loved ones deployed in Iraq or Afghanistan, be assured that, should they be injured, they will receive trauma care that is unsurpassed by any trauma system here in the U.S. My time at LRMC and at the 332nd have been life-changing for me, both personally and professionally, and I look forward to a continued association with my military colleagues as we work together toward establishment of a worldwide military trauma system. For no matter what your views are on this war or any war, we owe our brave soldiers, airmen, sailors, and marines the very best trauma care that we can deliver. In addition, we owe the patients in our trauma centers at home the chance to benefit from the scientific discoveries coming out of this conflict—that is, after all, our obligation as surgeons. Ω

Acknowledgments

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