

# The 2004 Fitts Lecture: Current Perspective on Combat Casualty Care

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I would like to thank the American Association for the Surgery of Trauma and President Cryer for the opportunity to deliver the 2004 Fitts Lecture. When Dr. Cryer asked me to deliver this lecture, I actually wondered whether he had called the wrong number. Dr. Basil Pruitt described Dr. William P. Fitts in his 1992 Fitts Lecture as a ‘physician soldier in World War II, an author, a chairman, an editor of the *Journal of Trauma*, and a past President of our association’.<sup>1</sup> To deliver a talk named after such an esteemed surgeon soldier is indeed a privilege. So, as Commander of the U.S. Army Institute of Surgical Research (USAISR), and Trauma Advisor to the Army Surgeon General, I am here to represent the men and women who serve in uniform, and I hope to do them justice today. At this point, I would like all Operation Iraqi Freedom and Operation Enduring Freedom personnel to please stand and be recognized.

Dr. Donald Trunkey discussed his experiences as a deployed Chief of Professional Services of the 50th Field Hospital during Desert Shield/Desert Storm in the 1991 Fitts Lecture and in a paper in ‘The Archives of Surgery’ in 1993.<sup>2,3</sup> Subsequently, he lectured and wrote multiple after-action reports, resulting in numerous Government Accounting Reports about these experiences.<sup>4–10</sup> In summary, Dr. Trunkey believed there was significant room for improvement in our ability to care for injured casualties in a deployed setting. Dr. Basil Pruitt eloquently described the interaction between the AAST and military medicine.<sup>1</sup> Both men are retired Army Colonels who have spent the better part of their careers serving in the military. To prepare for this lecture, I went back and read their articles and reports and discussed their findings with the respective authors, among many others. Consequently, my approach in this Fitts oration is to tell you about the current medical story—where we are and what we are doing in Operation Iraqi Freedom and Operation

Enduring Freedom—to give you a flavor on what is going on right now, to discuss what has gone well, and, of course, to convey to you where I think we could do better.

My comments are based on the five visits I have made to Iraq as the Trauma Consultant for The U.S. Army Surgeon General. In Iraq, I have had the honor of working with many deployed units, operating on wounded Soldiers and Marines at different locations throughout the country. I have had the privilege of talking to many surgeons, nurses, and medics about their clinical practice, discussing logistical and communication challenges, and the training they thought they should have had or did have that made a difference in their care of casualties. We also discussed the research requirements that have been generated by this war. Most of this lecture is based on their conclusions and observations.

On these trips into Iraq I was fortunate to travel with multiple teams of consultants and logistics personnel. We traveled from Kuwait City in the south up to Tallil, Babylon, Al Hillah, Karbala, Fallujah, Ar Ramadi, Baghdad, Baqubah, Balad, Samarra, Tikrit, Kirkuk, and Mosul. On one trip, I went into Jordan. Trips by consultants to observe battlefield medical conditions were common in WWII and Vietnam and were reinstated by LTG James Peake, the Army Surgeon General in 2003. He expressly wanted his consultants to deliver reports directly to him, from the docs, nurses, and medics doing the work. Traveling the country is an amazing experience whether in an open jeep or 5-ton truck, a C-130 aircraft, in a Marine CH-46 helicopter, an Army CH-47, or a Blackhawk. I even had the opportunity to walk, as a tourist-for-a-day, through the throne of Alexander the Great in Babylon.

## Field Facilities, Personnel, and Environment

The current (October 2004) medical force in theater consists of two combat support hospitals (CSHs) split into four locations. Additionally, there are seven Army forward surgery teams (FSTs), two Marine forward resuscitative surgery suites (FRSS), and two Air Force expeditionary medical support units (EMEDS) in Iraq. The FST, FRSS, and EMEDS are small, extremely mobile, lightweight 10- to 30-man units, set up to surgically care for seriously injured casualties. There are 19 helicopter locations, hundreds of ground ambulances, and thousands of medics/corpsmen providing Level I care.

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# Report Documentation Page

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**Fig. 1.** *It's a Different World.* Clockwise from upper left: avoiding bad road and driving across the desert; clearing weapons before meals; washing hands to get authorization for dinner; convoy travel in gas masks.

All the services—the Army, Navy, Air Force, and Marines—have deployed medical capabilities. Unfortunately, however, there is no overarching medical command for all these medical forces. I have visited the facilities of all three services and will try to generalize and describe situations that apply to all the services.

Dr. Trunkey discussed the problems generated by the professional filler system (PROFIS), which is the pool from which the military fills personnel vacancies in our deployed field hospitals. Unfortunately, Dr. Trunkey, I have to tell you that we still have problems with our PROFIS system. There is less waiting around now for PROFIS to fill spots than there was in January and June 2003. However, vacancies still are not filled fast enough, and the types of specialties that we place in our CSHs could be improved upon. Maj (Dr.) Mary Jo Wright, for instance, who is a member of our society, deployed as Commander of the 1st FST, and I have to say that I received many e-mails from her, loudly commenting on her experience of waiting and trying to create a cohesive FST from an inexperienced and understaffed unit. This process is improving, and a new system, using the knowledge of the

clinical consultants to place the correct mix of specialties, is being implemented.

I must mention the difficulty with communication and logistics that has plagued every deployed Army, dating back thousands of years. Unfortunately, the current war is no exception. Over time, much has improved, but communication and logistics are still less than perfect. The situation in May 2004 was a lot better than the same timeframe in 2003. It is a different world out there, and it takes time to adjust. The harsh reality of this environment is almost beyond comprehension. The snapshots in Figure 1 show what you might encounter on an average day. The picture in the upper left was taken as we drove over the desert because the desert was less bumpy than the road that was barely visible. You have to clear your weapon before you walk into eat, and if you do not wash your hands before a meal, you are denied access to the dining facility. Soldiers wearing gas masks any time of the day or night were not an unusual sight. Figure 2 is not out of focus—it was taken through a clear lens. This is what daylight looks like in a sandstorm, an all too common occurrence. Convoy



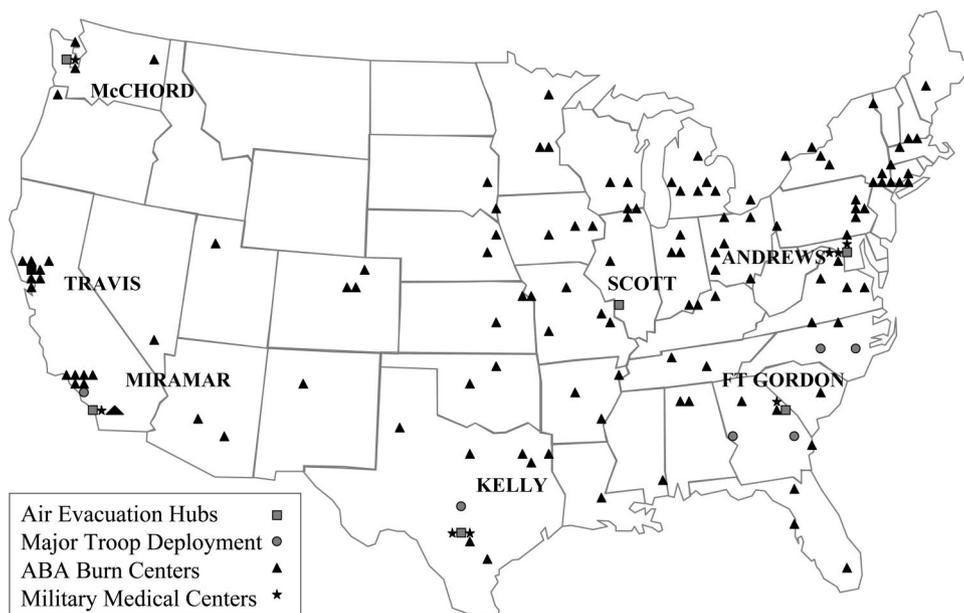
**Fig. 2.** Desert dust storm midday.

operations are extremely difficult, with frequent breakdowns.

### Burn Care

The Army Surgeon General has designated the USAISR the major receiving site for all significant burn casualties. We work closely with the U.S. Air Force to rapidly move all casualties requiring burn center care to the ISR. In addition we were designated the receiving center for the expected vesicant injuries, which fortunately did not materialize in this conflict. USAISR has trained over 1,200 deploying personnel in burn care, deployed four surgeons into theater, and received 249 significant burn casualties and completed 35 burn flight missions thus far. We were also charged by the Army Surgeon General to prepare a plan for burn triage if burn casualties overwhelmed the USAISR bed capacity (40 beds)

and to fly burn casualties to the 60 American Burn Association (ABA) verified burn centers (Fig. 3) in proximity to the USAF hubs.<sup>11</sup> We anticipated between 500 and 2,500 burn casualties and created a nationwide burn bed system that was updated daily. In close cooperation with the leadership of the ABA, we quickly created a system that delivered an accurate count of burn bed availability across the country. The Department of Defense (DoD) and the National Disaster Medical System (NDMS) used these data, and because we directly queried the clinical nurse managers or the senior burn surgeon daily at each of the ABA verified burn centers, the accuracy and quality of the burn bed availability was assured. Bed availability, quantified daily, was sent by automated report to approximately 70 personnel, including those in Germany, assuring that if there were massive burn casualties flown out of Iraq or Afghanistan to Germany, we would load the planes correctly so they would land next to centers with available burn beds. Once we were organized, this was a simple system to maintain and exercise and was done daily for the first 3 months of the war and has been used semiannually since then—most recently for the Paraguayan burn disaster. Figure 4 shows the average number of intensive care unit and ward beds that were staffed and available on any given day for the first 3 months of the war. This model has potential to expand to nonthermal trauma disasters and to fill a real need in our national trauma response system, which most speculate will more than likely be overwhelmed by conventional terrorist injury rather than nuclear, biological, or chemical attacks. Because this nationwide burn bed system merges location, the actual number of available intensive care unit and ward beds and the quality of the beds (ABA verified) into the system, it should be of interest to Office of Homeland



**Fig. 3.** United States air evacuation hubs close to arrival points where planes from Germany land; major troop deployment sites; and ABA verified burn centers and the military medical centers.

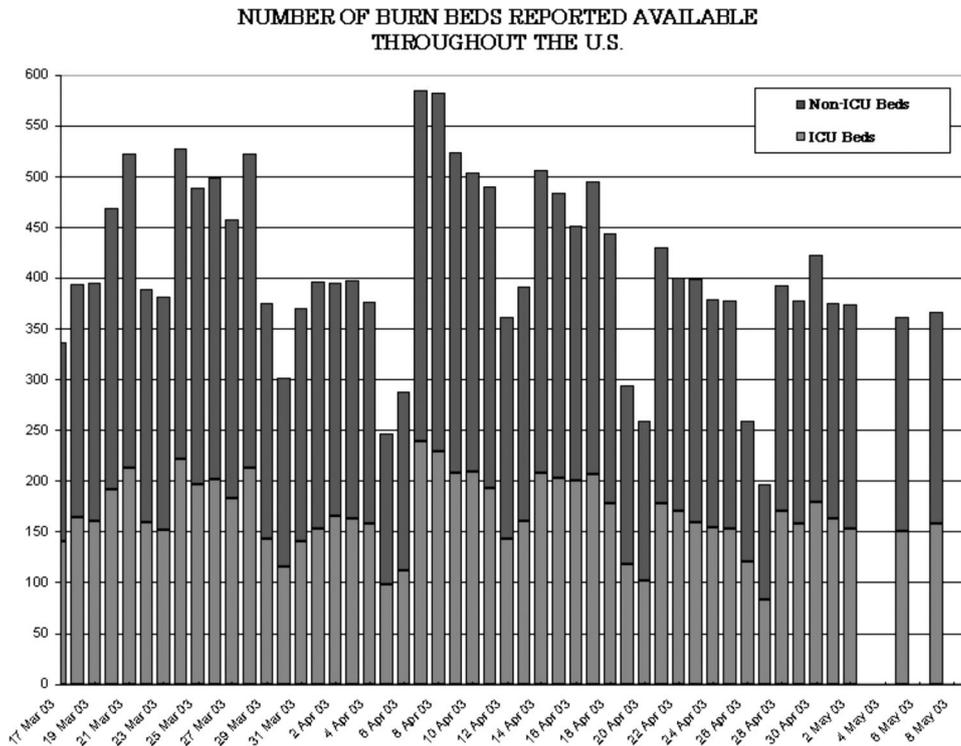


Fig. 4. Number of available burn beds throughout the U.S., March to May 2003.

Defense, the ACS Committee on Trauma, and the professional trauma societies. The same nonthermal trauma bed data should be available from the 703 American College of Surgeons-Committee on Trauma (ACS-COT) verified trauma centers in the United States.

### Trauma Epidemiology

Just as the national trauma database and local trauma registries are the backbone of performance improvement and have helped to improve treatment and outcome-based trauma care research, we need to know what is happening to our deployed troops so we can react and make improvements. Figure 5 shows the total number of injuries between May 2003 and September 2004 and shows that a huge increase in the trauma load occurred in April 2004 and continued on into

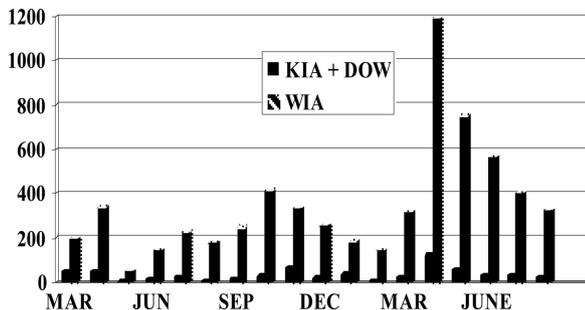
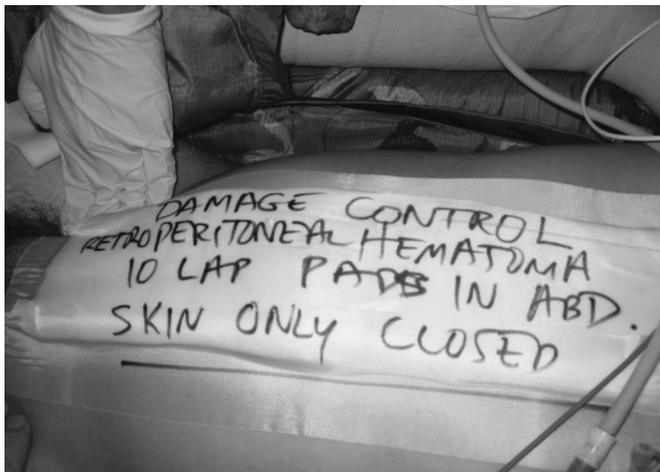


Fig. 5. Operation Iraqi Freedom, types of casualties, March to August 2004, from the Directorate for Information Operations and Reports, September 21, 2004. KIA, killed in action; DOW, died of wounds; WIA, wounded in action.

June, July, and August. We feel this reflects attempts by the insurgents to destabilize the Iraqi government. As of October 2004, combat deaths in the global war on terrorism stood at 721, with wounded in action over 6,000, ostensibly building the survivor rate to 88.6% compared with 76% in Vietnam.<sup>12</sup> Recently, however, we discovered that the definitions used to obtain the numerators and denominators to reach these percentages changed between Vietnam and the current conflict. This discrepancy really points toward the need for consistent application of basic injury epidemiology concepts to the war data.

In response to the lack of a DoD-trauma registry, we have created a joint theater trauma registry (JTTR) with impetus from the lessons learned in the civilian trauma sector. Through the efforts of the three Surgeons General and Health Affairs, a policy paper was published recently describing the minimum essential data elements needed to comprise uniform trauma data collection on the battlefield and to establish a JTTR.<sup>13</sup> The three services have agreed to individual service variations, but we will share common data elements, and Health Affairs is now directing us to capture injury data. These data will be stored at the USAISR and be available as a research database. For the first time, we will have ongoing data capture in the middle of a war. This will allow feedback to commanders, researchers, soldiers, and physicians, allowing us to react in a data-driven fashion to changing tactics and injury patterns to produce new interventions. The database architecture is based upon our experience with civilian trauma registries and is designed to allow us to compare



**Fig. 6.** Patient history written on the abdominal dressing.

elements and outcomes with the National Trauma Database. Dr. Howard Champion has been a leader in these efforts. One of the areas that we have really struggled with is reliable data transfer. (Just think of your issues with run sheets and transfer summaries in your trauma system and imagine doing this in a war zone, with transfers scattered over three continents, >15 hospitals, and sporadic to no email connectivity.) We feel that using the portable computer storage drives (thumb drives) may allow us to transfer data in a better fashion, and we may augment dog tags with thumb drives, allowing reliable transfer of digital x-rays, pictures, trauma history, and physical E-Forms on these devices. Hopefully, this will replace writing transfer notes on abdominal dressings (Fig. 6). We have started publishing monthly JTTR reports, and from these, will discover trends and impact of tactics and medical intervention and improve our trauma system.

An initial look at JTTR data reveals what you would expect: largely young casualties, 95% men, with almost 75% evacuated out of the theater if they arrived at a CSH. Anatomically, injuries are frequently seen in multiple sites and are predominantly to the extremities. Balad and Baghdad account for more than 90% of all the battle and nonbattle injury casualty care occurring in theater, 60% of which are extremity injuries. Despite reports to the contrary, the injury distribution has not changed appreciably since World War I. Extremity wounds have always been the predominant injury, head, neck, and face injuries account for 21% with a decreased percentage of chest injuries. Abdominal injuries remain similar to previous conflicts. (Table 1).<sup>14</sup> At this point, we have over 4,000 injury casualties entered and, in conjunction with the AFIP, 650 of 1,100 deaths coded. Attention is now focusing on scoring these casualties to complete their entire record of care.

The JTTR data are augmented by isolated pockets of unit specific data. Lt Col Brian Eastridge, who is a new member of the association and in the audience, collected data from the four CSHs currently functioning in Iraq and found injuries broken down into roughly the same categories. MAJ Owsley,

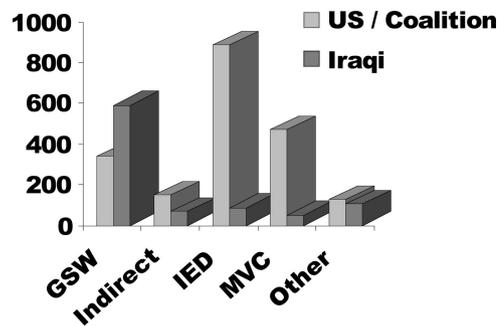
**Table 1** The casualty template

	Head and Neck	Chest	Abdomen	Extremity	Other
WW I	17	4	2	70	7
WW II	4	8	4	75	9
Korea	17	7	7	67	2
Vietnam	14	7	5	74	—
Northern Ireland	20	15	15	50	—
Falkland Islands	16	15	10	59	—
Gulf War (UK)	6	12	11	71	—
Gulf War (US)	11	8	7	56	18+
Afghanistan (US)	16	12	11	61	—
Chechnya (Russia)	24	9	4	63	—
Somalia	20	8	5	65	2
GWOT	21	4	6	58	10

Modified from the Emergency War Surgery handbook.<sup>31</sup>

who is also in the audience, reviewed almost 600 casualties at one hospital, noted 650 procedures and 750 injuries, and then broke these down into 31 different injury locations. Consolidation of 31 recorded injury sites into four major sites of upper and lower extremity chest, i.e., abdomen, pelvis, head, and neck, resulted in the same distribution seen by Lt Col Eastridge and others. Figure 7 is interesting because of the differences in the patterns of injury between Iraqis, who more often suffer single gun shot wounds, compared with the U.S. and coalition forces. Important from a prevention point of view is that during this phase of the war, more U.S. and coalition casualties occurred after motor vehicle crashes than gun shot wounds. During the January to March 2004 time-frame, survival was not improved by soldiers going to one of the smaller FST surgical facilities rather than going directly to a CSH. During this time, more than 75% of the casualties went directly from point of injury to a CSH, appropriately bypassing the less capable forward surgery teams. Significant effort has been generated by the medical leadership to accelerate this trend, which I will discuss at greater length later in this presentation.

Comparing the civilian data from Sauaia et al.,<sup>15</sup> COL Ron Bellamy's Vietnam data,<sup>16</sup> and Maj Owsley's data from the 1st CSH in Baghdad (Table 2) reveals that the leading



**Fig. 7.** U.S. versus Iraqi patterns of injury, courtesy of Lt Col Brian Eastridge, MC. GSW, gun shot wound; IED, improvised explosive device; MVC, motor vehicle crash.

**Table 2 Etiology of death: civilian vs. military**

	Civilian 15 (%)	Military 16 (%)	31 CSH <sup>a</sup> (%)
Hemorrhage	39	47	56
CNS	42	36	36
Multiple	12	13	8
MOF	7	4	
Unknown			

CNS, central nervous system; MOF, multiple organ failure

<sup>a</sup>MAJ Jimie Owsley, 31 CSH, unpublished material, Iraq 2004.

During this time, the 31st CSH was the only neurosurgery center in Iraq.

causes of death from these three different samples are hemorrhage and head injury. A survey of Vietnam data recently published by Blood et al.<sup>17</sup> and autopsy data from a busy civilian Level I trauma center published by Cohn and colleagues arrived at similar conclusions.<sup>18</sup> We recently obtained IRB approval to study more than 1,100 combat deaths, and this should result in a complete picture of the epidemiology of combat injury and death on the modern battlefield. Contrasting these different populations will allow us to learn just what the causes of death on the current battlefield are and what equipment, training, personnel, and research are required to counteract the current weapons effects. This war is significant for the widespread appreciation and use of individual protective equipment, including head, eye, neck, groin, and chest protection. Body armor does not always work (or is not always worn), as evidenced by the significant chest and abdominal injuries documented in the theater trauma registry. However, MAJ Owsley's data documents 14% chest and abdomen injuries for U.S. casualties compared with 27% for the same type of injuries for the Iraqis who do not wear body armor; you can believe that body armor is making a difference. Both groups have exactly the same distribution of extremity injuries (Table 3).

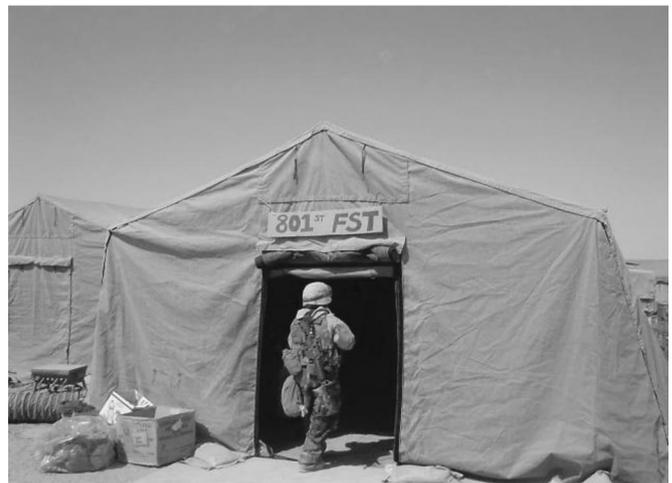
**Optimal Use of the FST**

Balanced use of the three services' small, mobile, surgical teams on the changing battlefield is key to improving survival. Early in the war, during the maneuver phase, the forward surgery units were the only such unit that was small and mobile enough to set up, tear down, and move with the armored column. After the larger and heavier CSH (Level III)

**Table 3 Operation Iraqi Freedom: distribution of injury, U.S. military versus Iraqi prisoner<sup>a</sup>**

	U.S. Military	Iraqi Prisoner
Total number patients	598	144
Total procedures/injuries	654/750	257/209
Head/neck (%)	229/750 (31)	31/209 (15)
Trunk (%)	102/750 (14)	57/209 (27)
Upper extremity (%)	221/750 (30)	50/209 (24)
Lower extremity (%)	198/750 (26)	71/209 (34)

<sup>a</sup>MAJ Jimie Owsley, 31 CSH, unpublished material, Iraq 2004.



**Fig. 8.** Two pictures illustrating the difference between mobile temporary FST (bottom) and more permanent CSH (top).

facilities arrive and set up, the FSTs should collapse into the CSH or redeploy home. The capability of the FST to physiologically care for the most critically injured casualty is necessarily limited when compared with the larger and more equipment heavy and capable CSH, whereas those casualties with less severe injuries do not have time-sensitive injuries. Because of their weight and personnel constraints, the ability to diagnose and optimally treat the hypothermic, coagulopathic, and acidotic casualties in a FST is limited, especially with multiple casualties. It must be emphasized that this is in no way a negative comment on the medical ability of the personnel serving in these necessarily austere facilities. The features that makes the FST so good during the maneuver phase are the same that mandate they should be overflowed later in the war when a CSH is close by (often within 10–30 minutes). This situation is analogous to the civilian trauma systems approach where legislation directs bypass of smaller hospitals and delivery of critically injured patients into larger, more capable trauma centers.<sup>19</sup> Figure 8 highlights the differences between these types of facilities. The 21st CSH in Mosul had a large number of tents, two operating rooms, an intensive care unit, landing zone, vehicles, and several hun-

dred personnel, as opposed to a typical FST in the desert with two tents and 20 personnel (limited Packed red blood cells (PRBCs), no FFP, and limited laboratory, x-ray, and rewarming capability). Again, based on the civilian trauma system experience, it is expected that the survival for patients taken to a CSH will be higher than for those taken to FSTs. An extreme comparison of the pros and cons of small and mobile versus large and fixed is the CSH set up in the Ibn Sena Hospital in Baghdad, which is not mobile. At one point, several FSTs were within a 10-minute flight of this facility. Unfortunately, some Commanders have been unwilling to “let go of their hospital,” and the medical leaders on the battlefield do not have control of these surgical assets. Current medical recommendations are for FSTs to be used only if flight times are longer than 90 to 120 minutes from a CSH.

## Hypothermia

An article in a 1918 issue of the *Journal of the American Medical Association*, “The Preventive Treatment of Wound Shock,” by Cannon et al.<sup>20</sup> is famous as a resuscitation paper; however, three quarters of the paper addresses hypothermia. Hypothermia secondary to hemorrhagic shock is as bad a problem now as it was in 1918. Hypothermia, coagulopathy, and acidosis occur in the sickest of military casualties, no differently than civilian casualties, except that this deadly triad is more difficult to reverse in a hypotensive casualty in the desert. It is much better to prevent hypothermia from happening in the first place, and the DoD is focusing on developing a coherent hypothermia strategy. In the meantime, some of the reported expedient solutions have included placing a light bulb in a cardboard box to warm IV fluids up to 40°C, the innovative use of the meal ready to eat (MRE) warming units for warming a liter of Ringer’s lactate to 44°C, a hand-held hair dryer and cardboard box unit that can be placed over casualties in a bed, which allows efficient warming when bed huggers are not available, and finally, a radiator that was pulled off the wall and stuck under a sheet next to the casualty. Soldiers recognize that keeping the casualties warm saves lives, and their inventiveness is amazing. Commercial products, such as Bair Huggers, Belmont Rapid Infusers, and Belmont Buddies (Belmont Instruments, Billerica, Massachusetts), Thermal Angels (Estill Medical Technologies, Inc., Dallas, Texas), and improved blankets designed to retain heat such as the Blizzard Survival Blanket (Blizzard Protection Systems, Bethesda, United Kingdom) and the Ready Heat Blanket (TechTrade, Potomac, Maryland) will prevent and treat hypothermia. These devices are becoming more readily available as our logistic system places these commercial off-the-shelf items in the deployed setting.

## New Products

The newest technology on the battlefield can be found in shelters, medical items, and communication devices. The Chemically and Biologically Protected Shelter System (CBPSS), documented in the August 2004 issue of the *Jour-*

*nal of Trauma*,<sup>21</sup> is a small mobile chemical protective shelter that has been used to shield some of the small surgical teams, allowing them to set up in under 10 minutes and operate in an air-conditioned, and more importantly, a clean environment.

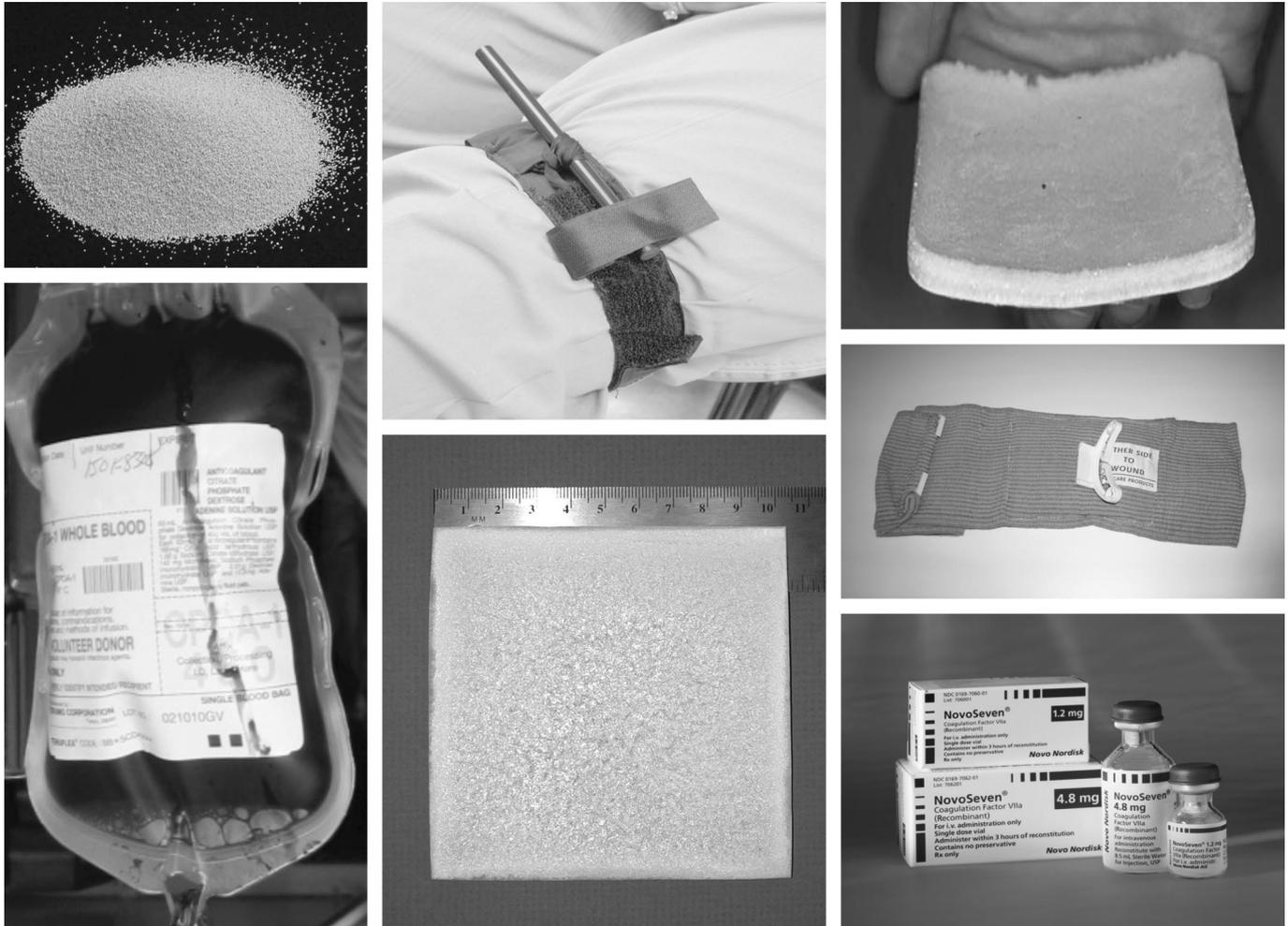
## Hemostasis

Hemostasis is an area of research that has seen considerable improvement. Ten years ago, the DoD recognized that hemorrhage was the leading preventable cause of death on the battlefield. Since then, we have fielded seven new hemorrhage control products into the hands of medics and surgeons (Fig. 9). Many of you in this room have contributed to the introduction of these helpful products, and we thank you. These products include new tourniquets and new guidelines for tourniquet usage, improved hemostatic products—from powders to dressings to better gauze and advanced hemostatic dressings—IV hemostasis with fresh whole blood, and recombinant coagulation factor VIIa (Kauvar DS, et al., unpublished material, 2005).<sup>22–26</sup> Rather than approach the problem of hemorrhage in a linear fashion, the DoD has deployed multiple products at multiple levels to improve hemorrhage control across the board. Wide use of these products and, perhaps more importantly, even wider appreciation of the importance of early hemorrhage control has likely resulted in a decrease in the killed in action rate.

Other new devices are oxygen generators, IV pumps, wound vacuum assisted closure (VAC) therapy devices, handheld ultrasound, pain pumps, and digital radiograph. The latter device saves images on electronic media and removes the environmental problems associated with handling chemicals for film development. However, despite the fact that technology is important, I will tell you that the best instruments on the battlefield are your hands, fingers, and brain, trained for optimal use. They seldom break, they are hard to misplace, they can be upgraded continuously, and frequently invent new solutions.

## Trauma Training

The DoD has had an intensive 6-year focus on trauma training. Initially, this training was largely centered on the small surgical teams starting at the Joint Trauma Training Center in Houston, Texas, under the auspices of Dr. Ken Mattox. I was fortunate enough to help initiate this program, and we trained 16 surgical teams from the three services from 1999 to 2001, expanding from basic surgical teams to include the Critical Care Air Transport Teams from the USAF.<sup>27–29</sup> Since 2001, each service has had its own dedicated training sites and continued to train deploying teams. I would like to thank the trauma leaders in the audience from the centers at LA County, Miami, Baltimore, New York, Houston and Cincinnati for their efforts. Many other sites have established their own civilian/DoD training centers. From talking to many deployed surgeons, nurses, and medics at all levels of care, I can tell you that all feel that this type of training was



**Fig. 9.** Examples of new drugs and devices for hemostasis. Clockwise from upper left: QuikClot (Z-Medica, Wallingford, CT); combat application tourniquet (CAT); fibrin sealant dressing; Israeli dressing; NovoSeven recombinant coagulation factor VIIa (NovoNordisk, Princeton, NJ); HemCon dressing (HemCon Inc., Portland, OR); and bag of fresh whole blood.

critical and saved lives on the battlefield. You should all be proud of your efforts.

One of the two most important training manuals for combat casualty care is the *Emergency War Surgery Handbook*, written by military surgeons for surgeons.<sup>30</sup> The text is a basic how-to book, and for those who are deploying, it is designed to be the one surgical book that you grab as you go out the door. Second is the complementary text for medics, Chapter 16 of the *Prehospital Trauma Life Support (PHTLS)* manual from the ACS-COT on Trauma and the National Association of Emergency Medical Technicians.<sup>31</sup> This chapter is the basis for the Tactical Combat Casualty Care (TCCC) course, and is written by the Committee on Tactical Combat Casualty Care (COTCCC). This multiservice and multidisciplinary committee is based upon the principles of the ACS-COT and regularly updates TCCC. Initially, this section of the PHTLS was used only by Special Operations Forces, but because of its straightforward instructions and applicability, is now used by most conventional forces. It is the standard at most of the services' training schools for medics. The dedi-

cated work of CPT Frank Butler and Dr. Norm McSwain should be recognized for leading the prehospital tactical combat casualty effort.<sup>32</sup> They and others expanded upon the approach of good tactics and good medicine that was first described by CPT Butler.<sup>33</sup> The focus is primarily hemorrhage control, needle thoracentesis and then airway, merged with the concept of finishing the mission and not getting hurt. So, as opposed to the classic ABCs taught in civilian ATLS, TCCC appropriately teaches C, B, A. This is based on the epidemiology of combat injury and the tools available to medics to effectively intervene. Hemorrhage control with liberal tourniquet use and advanced hemostatic dressings is paramount. Combat extremity injuries are devastating and unfortunately extremely common. There is really no comparison in the civilian experience. Tourniquets are extremely cheap, useful, and effective, and all soldiers will soon carry one. Tension pneumothorax is easily treated with simple 14-gauge needle thoracentesis. Endotracheal intubation is relatively unusual because many penetrating wounds to the face can be temporized by lying in the recovery position, a lesson

learned in World War II, forgotten, and only recently revived. Hypotensive resuscitation with a colloid solution is the preferred resuscitation technique in the field. Avoiding the typical civilian fluid controversy, from the military point of view, it is better to carry a colloid than a crystalloid because of their beneficial cube and weight issues on the battlefield.<sup>34</sup> The tactical endpoints for resuscitation are to titrate to a palpable radial pulse and normal mental status. As described by Cannon in 1918 and Beecher in 1944, hypotensive resuscitation was the technique of choice on the WWI and WWII battlefields.<sup>20,35</sup> Bickell et al.<sup>36</sup> revived this theory in 1994. Before wholesale adaptation of this approach, we needed to determine when the “clot would pop” and thus validate the empirical but uncontrolled findings of Cannon and Beecher. Dr. Jill Sondeen demonstrated that after arterial injury and hemorrhage, followed by spontaneous clotting, if resuscitation commences and continues until the blood pressure reaches a systolic blood pressure of  $94 \pm 3$  mm Hg, then newly formed clot is disrupted, bleeding resumes, blood pressure goes down, and the animal dies.<sup>37</sup> In other words, the basic tenet of hypotensive resuscitation is to maximize the beneficial metabolic aspects of resuscitation, staying below the rebleeding point and to avoid popping the clot and causing fatal rebleeding. The findings of Dr. Sondeen merge perfectly with the clinical observations of Cannon and Beecher and many others. These observations have been corroborated on the current battlefield. Once again the goal is to meld smart tactics and smart medicine for the benefit of the casualty and the care providers.

Prehospital pain control in tactical combat casualty care phase consists of Tylenol, oral transmucosal fentanyl citrate (OTFC) lozenges, and other single oral-dose pain medications that do not alter the coagulation system.<sup>38</sup> Aspirin and standard nonsteroidal antiinflammatory drugs (NSAIDs) are avoided because of their detrimental effects on platelet function, whose optimal function on the battlefield is clearly important.<sup>39</sup> These new and innovative approaches try to find a middle ground between no pain medication at all and jumping straight to IV morphine. Recent advances in pain control during the evacuation phase have, likewise, been well received.<sup>40</sup> Medic delivered prehospital antibiotics consist of 400-mg tablets of gatifloxacin, taken as soon as possible after any combat injury that breaks the skin and does not involve hemodynamic compromise. If the patient is in shock with a decreased mental status or radial pulse character, IV or intraosseous (IO) antibiotics are indicated.<sup>41</sup> Combat pill packs are now distributed by the Special Operations medics who, in their longstanding tradition of practical solutions, consolidated all the pills into one package. The injured soldier simply opens the pack and swallows all four pills.

## **Surgery on the Battlefield**

Damage control surgery is widely used on the battlefield. The key is early identification of casualties in the emergency department or in the triage area that most urgently require

these techniques. In many field locations, the first step is to call for fresh whole blood. Use of recombinant coagulation factor VIIa in conjunction with fresh whole blood is now routine at many sites. The focus is to stop bleeding and contamination, avoid hyperthermia, coagulopathy, and acidosis, use vascular shunts, perform rapid external fixation or splinting of extremity injuries, and transport casualties to a higher level of care as soon as possible. Whereas this is a familiar paradigm for civilian damage control, the combination of damage control and rapid evacuation across three continents creates special challenges at each step of the evacuation chain. Before the war started, there was some question about whether patients with open abdomens could be transported. That answer is a definitive “yes,” and it now remains to be seen how military casualties fare compared with civilian damage control patients.

The following cases highlight the frequent use of damage control techniques and the need for a broad familiarity with all trauma procedures. In one instance, a U.S. soldier was in a convoy when an improvised explosive device (IED) blew a large wound in his neck, exiting from his back. His posterior chest wound was packed, and a right anterior thoracotomy performed with thoracic packing and pulmonary tractotomy. His subclavian vessels and mediastinum were uninjured. Postoperatively, he was hemodynamically stable, warm, and not bleeding. He was transported directly from the operating room table to the transport helicopter with blood hanging and accompanied by a specially trained critical care nurse from Level II to Level III. He arrived hypothermic and coagulopathic after the 20-minute helicopter ride, which emphasizes the need to continue rewarming during transport. Another casualty had a damage control laparotomy performed at Level II with packing of his retroperitoneum, skin closure, and then transport to Level III. The message written on his dressing told us the clinical information that we needed to know, resulting in a call for a fresh whole blood drive and prophylactic recombinant coagulation factor VIIa (Fig. 6). Upon relaparotomy, he had a large central retroperitoneal hematoma, inferior to the liver. His injury, in the ventral vena cava, just inferior to the right renal vein, was repaired. At the end of the case there was no coagulopathic bleeding, the patient had no other injuries, and he was transported stable 2 hours later on a C-17 to Germany and has done well. Another patient who was hypotensive and hypoxic after an explosion and a motor vehicle crash had a widening mediastinum on serial CXRs. He was at a location that did not have computed tomography, angiography, or other diagnostic capability, so he was given fresh whole blood and recombinant coagulation factor VIIa and was taken for an exploratory thoracotomy. Fortunately, he had a normal aorta and great vessels. This case distribution has direct implications for the training of military surgeons. Breadth of surgical experience is a requirement for all deployed surgeons, including chest and major vascular capability, required in approximately 10% of all operative cases.



**Fig. 10.** Clockwise from upper left: Evacuation by helicopter, a USAISR burn flight team; ground evacuation; and transport from a Level II to a Level III facility.

## Extremity Injuries

Extremity injuries, as I have already mentioned, account for 60 to 70% of all battlefield injuries. Fasciotomies are frequently performed, but we may need to do them more often to avoid development of compartment syndrome during the rapid evacuation of casualties. Since the beginning of the conflict (September 2001), there have been approximately 225 major amputations. Those performed in theater have largely been completion amputations when nothing could be done to salvage devastated extremities. Walter Reed Army Medical Center and Brooke Army Medical Center have been designated the DoD amputee centers and are providing world-class prosthetic care. The orthopedic physicians feel that external fixation is the transport method of choice, and this has really decreased the overall number of amputations secondary to improved soft tissue stabilization during transport. The use of wound VACs has decreased the number of major tissue transfer procedures and seems to have short-

ened the time for wound closure of many wounds for all the patients we care for—coalition troops and Iraqis.

## Summary

Evacuation out of theater is absolutely amazing and deserves special comment (Fig. 10). Surgical critical care routinely commences within 1 to 4 hours after injury, after transport by ground or air evacuation, using the small surgical teams or the mobile CSH. Communication is frequent via email between providers and it is not unusual to have critically injured casualties in an intensive care unit bed in the United States within 2 to 4 days of injury from the farthest reaches of Iraq or Afghanistan. The U.S. Air Force critical care air transport (CCATT) teams are making this happen.<sup>42,43</sup> They make it look easy, but I cannot stress the importance of the overall evacuation effort. The ISR Burn Team likewise frequently links with the CCATT teams and routinely brings patients back to the Burn Center in San Antonio, Texas, within 2 to 3 days of injury.

**Table 4. Combat care requires a complete set of surgical skills**

For 1,037 casualties, over a 6-month period, eight surgeons performed:

- 546 Soft-tissue washouts and debridements
- 210 Laparotomies
- 205 Orthopaedic hardware
- 149 Face and neck
- 103 Ophthalmologic
- 97 Craniotomies / spine
- 74 Major vascular
- 29 Chest
- 108 Nontrauma

Data courtesy of MAJ Jimie Owsley, MD.

Table 4 outlines the complete list of surgical skills required to be a combat surgeon. This is again information from Dr. Owsley who collected data on 1,037 casualties, reflecting the work of five to eight surgeons in Baghdad over 6 months: the distribution is typical of all busy combat hospitals, especially those with eye and neurosurgical teams. Is this the modern definition of the old style general surgeon or is it the new trauma acute care surgeon being discussed by the American Board of Surgery? I am not sure which one it is, but I can tell you we need them right now. I hope that the American Board of Surgery generates a recommendation soon; they may want to use this list of procedures as a template.

The increase in IED explosions has created a small group of surviving casualties who have significant primary pulmonary blast injury.<sup>44</sup> This has complicated the care of these patients in the intensive care unit. An intensive care unit patient with pneumonia, inhalation injury, multiple organ failure, diabetes, heart disease, or hypertension, requiring traditional nutritional, ventilator, hemodynamic, antibiotics, and surgical critical care is common in our civilian intensive care units every day. However, traditional intensive care unit teams do not exist in the deployed tent hospitals, so we often have to create *ad hoc* intensive care unit teams, frequently incorporating family practice doctors, cardiologists, pediatricians, general internal medicine physicians, and the occasional trauma critical care surgeon or pulmonologist. This is another area where improvements can be gained by deliberately placing intensive care unit teams in the Level III facilities.

The members of the deployed hospitals have done a magnificent job caring for the coalition soldiers, Iraqi citizens, prisoners, and children. The latter group deserves special mention. Sixty to 75% or more of all casualties cared for in these hospitals are Iraqis. They are not rapidly evacuated and often stay in a CSH for weeks. They are cared for in a most heroic fashion. To quote a young surgeon, 'we are the good guys on the battlefield,' and every medical treatment facility is living up to this goal. We must continue to care for these noncombatant casualties and the significant changes in doctrine, personnel, and logistic systems required for their

care. That is what the Geneva Convention (FM 27-10) says we are supposed to do and we do it, day in and day out, often at a great personnel sacrifice.

## Trauma Systems

I have already mentioned the trauma system approach. Lt Col Brian Eastridge and MAJ Henry Schiller who are both Reservists and have served as Trauma Director in Iraq, started the effort toward a trauma system based on civilian trauma systems concepts. In November 2004, we formally established the Trauma Medical Director and Nurse Coordinator at the Medical Command level in Iraq, now led by LTC Don Jenkins. There are five trauma nurse registrars at the Level III facilities and one Trauma Nurse Coordinator, LTC Debi Spenser. They are implementing the JTTR, performing regional morbidity and mortality conference (M&M), publishing clinical practice guidelines and flight SOPs, performing medical flight review, have an ongoing performance improvement program, doing web-based feedback on casualties, helping place surgical teams in optimal locations based upon need, developing the process whereby combat casualty research can be performed, developing prevention strategies, and using the gold book<sup>45</sup> modified for military applications as a guide. This effort has been supported by the three Surgeons General and the ACS-COT and their chairman, Dr. Wayne Meredith. These goals are ambitious, yet using the lessons learned in civilian systems research and applying those to the battlefield must occur.

## Battlefield Research

Deployed research with IRB approval is exceedingly difficult. What we anticipate in the next several months is developing a process whereby scientific review of trauma protocols is conducted by the USAISR, with Brooke Army Medical Center functioning as the deployed IRB, and the Medical Corps General Officer in theater holding the research assurance. We did perform one prospective trauma study of a Food and Drug Administration (FDA) investigational new drug (fibrin dressing). We deployed 1,200 dressings, trained 250 medics, and consented 2,500 soldiers in four countries before the war started. Soldiers agreeing to participate in the study wore a green tab on their dog tags. Enrollment was > 98%. The dressing was used once on a high groin wound and was life saving. Performing FDA type prospective studies on the battlefield is very challenging, demonstrated by the 25% loss of the dressings because of ongoing combat operations. The Armed Forces Institute of Pathology (AFIP), Defense Advanced Research Projects Agency (DARPA), and the USAISR have combined their efforts to develop a protocol whereby before a conventional autopsy a 16-slice, three-dimensional CAT Scan will be performed and the results integrated into the current injury database. Dr. Howard Champion and Dr. Richard Satava are leading these efforts. The AFIP has performed autopsies on all 1,100 casualties, and we are evaluating the results within the context of im-

proving body armor, training, and research requirements. Multiple retrospective studies are being performed on the effectiveness of damage control surgery, tourniquets, hemostatic dressings, fresh whole blood, recombinant coagulation factor VIIa, and outcomes using intensive care unit teams. The National Institutes of Health, the Canadian Defense Department, and the U.S. DoD have formed a resuscitation consortium called the ROC (Resuscitation Outcomes Consortium), focusing on translation of clinical practices leading to immediate change in practice. We consider this to be very important addition to the combat casualty care research program for the DoD. The initial focus of the consortium has been on optimal resuscitation, ventilation, and hemostasis strategies in trauma patients, with obvious implications for improved combat casualty care.

## CONCLUSION

To quote Hippocrates, "He who would become a surgeon should join the Army and follow it." Now I'm not saying Hippocrates was an Army recruiter; however, there are two in the back of the room and I would like for you to take advantage of your time at one of the outside booths and talk to them. Along the same lines, the AAST should consider a written proposal to the three Surgeon Generals, outlining a way to use the expertise that is common in the civilian trauma community, in a way that will help our deployed soldiers, sailors, and airmen.

So Dr. Trunkey, the Government Accounting Office and DoD heard your comments. We've made significant improvements, but much work still remains. In summary, we have improved body armor, trauma training, and education, hemostasis, widely used damage control concepts, and extended them. We've widely deployed the rapidly mobile surgical teams, we have better warming devices, and a fair amount of new technology. We are using rapid evacuation, we are implementing the trauma systems approach, and a process for IRB-approved research. We have even improved coordination between services.

Areas for improvement still exist. Better training in tactically sound prehospital combat casualty care needs to occur. Logistics and communications still need improvement. We are working on our professional filler system and must find ways for the small surgical teams to be sent home or collapsed into the Level III facilities after the mobility phase of after the war is over. Intensive care unit and burn teams need to be sent into theater. We are making headway on preventing and treating hypothermia, coagulopathy, and acidosis but need to do more. Attention needs to be focused on decreasing morbidity in the surviving casualties after their return stateside. We really need a unified Medical Command structure, so medical resources can be optimally placed on the battlefield. Finally, we need to improve the doctrine, personnel, and logistic support for the noncoalition casualties that in many cases comprise the majority of cases at the Level III facilities.

I would like to say thank you to the partners of deployed Reservist who must work harder during the deployment and welcome their returning citizen soldiers back to their jobs.

Thank you to my medical colleagues in all the deployed medical units who care for those who are injured and perform their mission so well.

Finally, thank you to the soldiers, sailors, airmen, and Marines who assume the risk and without question do what the president orders.

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