Organizational characteristics of the austere intensive care unit: The evolution of military trauma and critical care medicine; applications for civilian medical care systems

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Critical care in the U.S. military has significantly evolved in the last decade. More recently, the U.S. military has implemented organizational changes, including the use of multidisciplinary teams in austere environments to improve outcomes in severely injured polytrauma combat patients. Specifically, organizational changes in combat support hospitals located in combat zones during Operation Iraqi Freedom have led to decreased intensive care unit mortality and length of stay as well as resource use. These changes were implemented without increases in logistic support or the addition of highly technologic equipment. The mechanism for improvement in mortality is likely attributable to the adherence of basic critical care medicine fundamentals. This intensivist-directed team model provides sophisticated critical care even in the most austere environments. To optimize critically injured patients' outcomes, intensive care organizational models similar to the U.S. military, described in this article, can possibly be adapted to those of civilian care during disaster management to meet the challenges of emergency mass critical care. (Crit Care Med 2008; 36[Suppl.]:S275–S283)

Key Words: critical care; intensive care; emergency mass critical care; U.S. military; multidisciplinary critical care teams; intensive care unit organizations

"We did everything from delivering babies to simply providing morphine and a blanket to septic and critical patients, and allowing them to die."

—Hemant H. Vankawala, MD, NPR.org, September 7, 2005, Hurricane Katrina.

Austerity connotes a location in an underdeveloped region of the world, harsh physical environments, or combat zones. Austere conditions, however, can occur even in the most developed countries when there are constraints in the delivery of care such as loss of basic infrastructure, degraded communications, and movement. A recent example is the city of New Orleans during and after Hurricane Katrina.

The constraints in critical care anticipated during austere conditions often include the lack of highly technologic equipment associated with delivery of modern intensive care. Additionally, the perceived large logistic burden of providing critical care is another factor limiting current disaster response planning and management (1, 2). Subsequently, planners focus on prehospital, first responder, and emergency medicine and emphasize triage with early evacuation to definitive medical therapy (1–5). Disaster planning largely assumes that once patients are triaged, resuscitated, and evacuated, there are enough medical resources to care for these patients (2, 4). Unfortunately, shortages in critical care-trained providers and lack of realistic cohesive contingency plans for emergency mass critical care make it unlikely that the United States will be prepared to provide optimal intensive care support (2, 3–6). Only recently, in 2005, the Working Group on Emergency Mass Critical Care published recommendations for hospitals to improve critical care services for hundreds or thousands of critically ill patients injured from a bioterrorist attack (6). These recommendations, however, do not include the management of traumatic mass casualties in which the injury patterns and resource requirements might be significantly different from bioterrorism. Unfortunately, few discussions or plans have adequately addressed the requirements for, or provision of, critical care during large-scale national or international catastrophes (1, 2, 4, 6).

Despite the known austere operational environments imposed by combat, it was not until the 1990s that the U.S. military identified the lack of intensivist involvement in critical care capabilities in far-forward locations (4, 5). This led to the requirement and development of evacuation for severely injured patients to higher levels of care (4, 5). An intermediate solution to the provision of critical care in austere locations was the development of critical care aeromedical transport teams (CCATT). Created by the U.S. Air Force in 1994, CCATTs provide both postoperative critical care and immediate evacuation of critically injured soldiers to higher levels of care as well as definitive care thousands of miles away (4, 5). In 2002 and during the first years of Operation Enduring Freedom and Operation Iraqi Freedom (OIF), this important development bridged the lack of postoperative critical care capabilities at the combat support hospitals (CSHs) located in

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combat zones (4, 5). Currently, CCATTs continue to provide immediate evacuation of severely injured patients and improve care in worldwide locations where critical care is not available (5).

Realizing the importance of early medical and surgical therapy for injured patients, the National Disaster Medical System (NDMS) recently created three international medical–surgical response teams (IMSuRTs) to provide a mobile and flexible solution for operative and definitive care worldwide (1, 7, 8). The IMSuRTs can be deployed in addition to regional disaster medical assistance teams (DMATs) to support national disasters (1, 7). DMATs consist of five types, including basic, burn specialty, crush injury specialty, mental health specialty, and pediatric specialty, but currently do not include critical care (1). The NDMS coordinates this augmented support with local and regional disaster management teams (1). In this model of disaster response, significant limitations for the delivery of adequate critical care persist. For example, the IMSuRTs consists of 30 individuals (Table 1) without sustainable critical care assets and must be augmented in the austere environment (1, 7). Moreover, plans to evacuate the surge of critically injured patients to local and regional hospitals could be problematic given the limitations in our healthcare systems, including space in overcrowded intensive care units and shortages in critical care nurses as well as physicians (2, 5, 8). Additionally, local or regional hospital systems may be incapacitated by the disaster or rendered incapable to manage critically ill patients (5, 8). The current NDMS plan, put to the test during Hurricane Katrina, was not optimum. Despite prepositioning DMATs, one physician noted, "many of the sickest simply died here at the airport" (9). The Working Group on Emergency Mass Critical Care in 2005 also noted that, "Mass critical care could not be provided without substantial planning and new approaches to providing critical care" (6).

Table 1. Changes in specialty personnel may be required depending on mission requirements (1)

IMSuRT team
1. Team commander
2. Supervising medical officer (trauma surgeon or ED physician)
3. Trauma surgeons (2)
4. Specialty surgeon (orthopedic, plastics, pediatric)
5. Emergency medicine physicians (2)
6. Anesthesia/critical care specialist (1)
7. Registered nurses (10, including 2 ED, 2 operating room, 2 critical care)
8. Administrative officer
9. Deputy commander
10. Paramedics (4)
11. Respiratory therapist
12. Logistics staff (5)

IMSuRT, international medical-surgical response teams; ED, emergency department.

Over the last decade and specifically the 6 yrs since the beginning of Operation Enduring Freedom and now OIF, the U.S. military has continued to refine the management and medical care of severely wounded patients in the austere environment. It is estimated that over 6000 casualties, 3000 American casualties and an equal number of Iraqis, have received intensive care support at an American CSH in Iraq alone. Additionally, countless mass casualties and surges of patients during offensive combat operations requiring critical care support have been managed. Needless to say, the military medical system has continued to evolve with improvements in patient outcomes (10). The military also has extensive experience in humanitarian medical missions and operations other than war. This article describes the evolution of critical care organization in the U.S. military medical system, which can possibly be adapted to improve planning and preparation in mass emergency critical care for civilian disaster management.

Historical Perspective: Military Critical Care

Florence Nightingale is credited with cohorting the most severely injured soldiers closest to the nursing stations during the Crimean War and starting the concept of intensive care wards (11). It has been appreciated by surgeons throughout the world's conflicts that early surgical intervention after wounding, particularly for hemorrhage, thoracoabdominal wounds, and airway obstruction, could improve survival in combat casualties (12). These patients, who could not be transported without surgery and resuscitation, represented 10% of the casualties during World War II (12). The increased tactical mobility required in World War II compared with previous wars required that small surgical teams in mobile field hospitals be deployed in far-forward combat areas to manage these critically ill patients (12). Small surgical hospitals (30–60 beds) were augmented with auxiliary surgery groups to provide resuscitative and lifesaving surgical interventions (12). The success of forward surgical care led directly to the creation of a mobile army surgical hospital (MASH) (12).

The MASHs were rarely used for their intended purpose, as mobile surgical platforms during the Korean War or Vietnam War, as a result of the changing nature of the warfare (12). As a result of this and other medical systems failures, the U.S. Congress in 1979 mandated that U.S. third- and fourth-echelon hospitals (see Table 2) would be standardized among the military services (12). Consequently, the U.S. military developed the deployable medical systems (DEPMEDS), which describes the essential material, equipment, and hardware characteristics of several variations of modular hospital configurations (12). The DEPMEDS sets were finalized in 1987 and offered variable configurations to adapt to missions, location, mobility, and types of patients (12). Unlike the previous MASH units, DEPMEDS incorporated designs for an intensive care unit specifically to care for the most severely injured patients (12). Each intensive care unit has 12 beds with six mechanical ventilators and can monitor continuous electrocardiography, oxygen saturation, arterial and central venous pressure, capnography, and intracranial pressure.

The organization and staffing of DEPMEDS systems was addressed by Medical Force 2000 (MF2K) doctrine developed in the 1980s (12). For better comprehension, one must appreciate the framework of the military integrated health services support. This support system uses five levels of care or echelons to triage, treat, evacuate, and return soldiers to duty. See Table 2 for description of each level of care. The MF2K plan eliminated evacuation and station hospitals, replaced MASHs with level II forward surgical teams (FSTs) as well as created level III CSHs. Level IV field and general hospitals were maintained (12). The CSH, field hospital, and general hospital use modular concepts to exploit flexibility tailored to mission requirements (12).

In the integrated health system, the transition from emergency care to critical care typically occurs after advanced trauma life support interventions or operative intervention. Under the MF2K plan, the first Army critical care assets are found in the FST. The team consists of 20 persons with three general sur-

Table 2. Levels (echelons) of U.S. military medical care

Level I	
Immediate first aid at the scene	
	Self-aid, buddy aid, combat lifesaver (nonmedical team member trained in enhanced first aid)
	Care by combat medic (EMT-B), independent duty corpsman, special operations technician, pararescueman
Battalion aid station	
Shock trauma platoon (USMC)	
Level II	
Increased medical capability	
	Treatment platoons
	Forward surgical teams
	Mobile field surgical team (USAF)
	Small portable expeditionary aeromedical rapid response team (USAF)
	Expeditionary medical support basic (USAF)
	EMEDS +10 (USAF)
	Casualty receiving and treatment ship
	Aircraft carrier (CVN) battle group
	Surgical company (USMC)
	Forward resuscitative surgical system (USMC)
Level III	
Highest level of medical/surgical care in combat zone	
	Combat support hospital
	EMEDS +25 (USAF)
	Fleet hospital
	Hospital ships (USNS mercy/comfort)
Level IV	
Definitive medical/surgical care outside combat zone, but in theater	
	Field hospital
	General hospital
Level V	
Continental US-based hospitals providing ultimate treatment capabilities	
	Department of defense hospitals
	Department of Veterans Affairs hospitals
	Designated civilian hospitals

EMT-B, Emergency Medical Technician Basic; USMC, United States Marine Corps; USAF, United States Air Force; USNS, United States Naval Ship.

geons, one orthopedic surgeon, two nurse anesthetists, one operating room nurse, critical care nurses, medical–surgical nurse, and 11 technicians (12). The FST can be operational within 1 hr and provides lifesaving resuscitative surgery continuously for 72 hrs (12). Additionally, the team can provide postoperative intensive care for eight patients up to 6 hrs (12). The level III CSH provides 144 operating room table hours per day and hospitalization for 296 patients, including 96 intensive care patients (12).

The U.S. Army defines intensive care units as wards where nursing care is performed for those patients who require close observation and vital signs monitoring, complex nursing care, and mechanical respiratory assistance; in each 12-bed ward, intensive care is provided by a staff of a clinical head nurse, clinical nurses, a ward master, practical nurses, respiratory therapist, and medical technician (13). This definition implies that intensive care is simply cohorting the most severely injured patients to provide closer observation and nursing care as was described by Florence Nightingale. This definition, however, does not incorporate the modern concept of critical care, whereby an intensive care unit is a specially staffed (with a multidisciplinary team) and equipped separate and self-contained section of a hospital to provide special expertise and facilities for the support of vital functions. In fact, the second edition of the *Emergency War Surgery* manual published in 1988 only mentions the application of critical care concepts to say that, "The combat surgeon must not expect to find available the same spectrum of resources as are found in the civilian surgical intensive care ward" (14). Unfortunately, the U.S. Army's concept of intensive care and the evolution of modular and mobile far-forward surgical care deviated significantly from the simultaneous evolution of critical care in the United States.

Ironically, the history of intensive care medicine in the United States is intertwined with military medical history. Briefly, the first intensive care units created in 1953 developed in small numbers throughout the 1960s to support the postoperative management of patients after cardiac surgery as well as the management of airway and breathing in critically ill patients (11, 15, 16). In 1967, the identification of DaNang lung or shock lung in the Vietnam War and posttraumatic lung resulting from other noncombat-related trauma prompted Ashbaugh and colleagues to describe the clinical entity now known as acute respiratory distress syndrome (ARDS) (17). The high mortality and skills required to manage patients with ARDS created the necessity for sophisticated hemodynamic monitoring, advanced mechanical ventilator management, and skilled nursing (17). Increasingly throughout the 1970s and 80s, U.S. intensive care units developed 24-hr/day, 7-day/wk physician commitment to manage the most critically ill patients (11). The concept of critical care as a subspecialty of medicine is relatively new. The Society of Critical Care was only formed in 1971 followed by the recognition of critical care medicine as a subspecialty in 2006. Only in the last decade has literature acknowledged the improved outcomes associated with dedicated intensivist-directed multidisciplinary critical care teams.

The increased complexity of critical care pathophysiology and rapid development of novel diagnostic and therapeutic technology found in the evolving state-of-the-art intensive care unit require specialized knowledge, training, and skills as well as reliance on a multidisciplinary team approach. To this end, many institutions have implemented care with either an "open" or "closed" intensive care unit model (15, 18). In the open system, patients are admitted to a primary care physician or surgeon. In many open intensive care units, intensivists are available for consultation. In the closed system, patients requiring intensive care unit admission are transferred to the care of a critical care specialist or team. Another model includes transitional units, which include an intensivist director, trainees, and an intensivist team that comanages care with the primary physician while the patient is in the intensive care unit (18). Although the merits of each system have been debated, several studies have identified significant improvements in mortality, hospital/intensive care unit length of stay, resource use, improved patient and family satisfaction, and higher levels of intensive care unit nursing support and confidence in the closed and transitional intensive care unit model (15, 19–25). The mechanisms for differences in outcomes are complex to differentiate, but have been attributed to decreased complication rates, increased physician availability, management style, or some combination thereof (26). The median absolute reduction for mortality from an intensivist-directed model is 10% (21). Therefore, for every 10 patients treated after changing to an intensivist-directed model, one additional life will be saved, far exceeding any one single known intensive care unit intervention to date, including activated protein C (27).

Pronovost et al. evaluated the effect of intensive care unit organizational characteristics and found, as expected in multivariate analysis, that several unmodifiable factors such as comorbid illness and age were associated with in-hospital mortality (20). Interestingly, however, the biggest factor in mortality was lack of intensive care unit rounds by an intensivist, which was associated with a threefold increase in death as well as increased risk of cardiac arrest, acute renal failure, septicemia, platelet transfusion, and reintubation (20).

The Leapfrog initiative formed as a tool for large corporations to determine best practice models also identified that outcomes and subsequently long-term cost were improved in intensive care unit organizations with a dedicated full-time intensivist (21). As a measure to promote cost savings, the Leapfrog group and some insurance companies have both recommended or mandated their insureds seek care at only intensivist-staffed hospitals.

In 2001, the Society of Critical Care Medicine (SCCM) published an analysis of a best practice model for intensive care unit management (18). Their evaluation of the literature, however, did not delineate a best practice model because one model has not clearly stood out, although they did identify factors that related to improved outcomes measured by mortality, improved efficiency, decreased length of stay, or decreased cost (18). Factors identified included: a) timely and personal intervention by an intensivist; b) intensivist addition to the critical care team reduced mortality in academic centers; c) intensivist involved in administrative roles that provide benchmarking, clinical research, and standardization of care reduces length of stay, cost of care, and treatment complications; d) critical care pharmacist reduces adverse drug events; e) excessive nursing workload increases mortality; and f) the presence of a full-time respiratory therapist dedicated to the intensive care unit decreases intensive care unit stay, ventilator days, and overall intensive care unit costs (18).

A 1993 study by Zimmerman et al. evaluated organizational practices that were associated with higher intensive care unit outcome performance and identified several best practices (28). Within the intensive care unit, some examples included the use of specific guidelines and protocols for medical and nursing care, physician credentialing for selected invasive procedures, multidisciplinary physician team rounds, conferences, and decentralized services to name a few (28).

Although the civilian concepts of physician-directed intensive care units and multidisciplinary teams evolved and critical care literature pointed toward significant outcome improvements in intensivist-directed intensive care unit models and use of evidence-based practices, the U.S. military continued to rely on organizational models developed in the 1980s, before the recognition of the improved outcomes associated with intensivist. As a result, the MF2K doctrine did not anticipate the requirements for intensivist to staff FSTs and CSHs. Of note, astute clinicians who authored the third U.S. revision of the *Emergency War Surgery* manual published in 2004 had already come to the conclusion that, "Each battlefield ICU should have a dedicated intensive care physician due to the severity and lethality of blast and high velocity wounds, and the need for ongoing resuscitation of casualties requiring damage control" (29).

The U.S. Air Force has developed a lightweight, mobile, highly capable, clinically flexible, modular, and functionally organized critical care package that can be integrated or augmented to larger mobile medical systems and always ready to go. This platform is called small expeditionary aeromedical rapid response (SPEARR) team. The SPEARR Team consists of a five-person mobile field surgical team, a three-person expeditionary critical care team, and a two-person public health team. This team represents the first-to-scene module of the basic Air Force expeditionary medical support hospital capable of full operations within hours of arrival. Although the sustainment of its operations is reliant on casualty evacuation and resupply, it is a very capable and robust medical asset. The Air Force Medical Service's concept of operations includes the SPEARR team as a package that functions as an independent medical resource in austere conditions or as an early modular medical building block in a large number of contingency scenarios.

In its barest configuration, the SPEARR uses backpacks, medical bags to provide medical care as well as personal bags. Two days of potable water is man-carried along with food in the form of military meals-ready-to-eat. A 1-kW generator is also carried. Clinical facilities and lodging are found in structures of opportunity. Ten damage control surgeries or 20 nonoperative resuscitations can be performed before resupply. The expeditionary critical care team provides critical care for three mechanically ventilated patients simultaneously and has the equipment and supplies to care for 10 perioperative or other critically ill patients over a 72-hr period.

The Evolution of Critical Care in the U.S. Army: Operations Iraqi Freedom and Enduring Freedom

Recent interest and efforts have been dedicated to developing a joint Iraqi and Afghanistan theater trauma system to evaluate and decrease all-cause mortality from battlefield injuries (10). As a result of changes in combat casualty care (improved medic training, improved personal protective equipment, rapid evacuation), killed in action rates, which during previous conflicts ranged from 15% to 25%, have decreased to less than 12% during Operation Iraqi Freedom (10, 30, 31). Unfortunately, the number of patients who reach medical care and died of wounds (4.1%) has increased since the Vietnam War (3.0%) and World War II (3.5%) (10, 30, 31). The exact reasons for this are complex, but one explanation includes that because less casualties die on the battlefield (killed in action), more severely injured casualties survive to reach medical care. This creates the challenge of managing the most severely injured casualties that previously would have died in earlier conflicts (10). The most common cause of death in the first 24 hrs is secondary to hemorrhage and physiological exhaustion, whereas greater than 24 to 48 hrs causes include sepsis and complication from shock (10). During the Vietnam conflict, the wounds data and munitions effectiveness team reported that 12% of battlefield casualties died of potentially treatable causes, including sepsis, infection, and complications of shock (30). In fact, a recent review of the most critically injured patients requiring massive transfusions at a CSH in during OIF (n = 247) demonstrated all-cause mortality in this group was 40% with a significant proportion dying as a result of late complications encountered in the intensive care unit setting (32). Therefore, a large portion of potentially preventable death from battlefield injuries occurs in the intensive care unit setting. Interestingly, the intensive care unit of a CSH consumes more intensive care unit beds than the average civilian hospital. We found that patients in the intensive care unit accounted for 35% of all CSH admissions to the intensive care unit compared with less than 20% of civilian trauma center patients (33).

The shift to stability operations has changed the CSH mission from primarily a surgical hospital to also include the medical management of host nation and coalition support personnel, many with significant comorbid medical conditions. Over 20% of admissions to the 31st CSH in 2004 were for medical reasons and this resulted in a significant proportion of intensive care unit admissions for cardiac causes, infectious disease, and pulmonary diseases (Jeremy Perkins, MD, personal communication). Furthermore, the primary patient population consisted of American or coalition casualties, in which traditionally patients were evacuated in less than 48 hrs, causing little impact on the intensive care unit for space and ongoing critical care services. The CSH mission, however, has progressively changed to provide increased local host nation care for patients unable to transfer until medically stable, thereby increasing the need for intensive care unit services. Currently, over 50% of intensive care unit admissions are now attributable to Iraqi Nationals, some of whom require prolonged intensive care unit care (Jeremy Perkins, MD, personal communication). The addition of neurosurgical services to a CSH also mandates increased intensive care unit space and services because patients commonly require several days of intensive care unit management before they can be evacuated or transported.

High-acuity utilization of important resources and numbers of potentially treatable intensive care unit deaths makes the organizational characteristics of the intensive care unit in a CSH an important factor in the continued development of a joint theater trauma system.

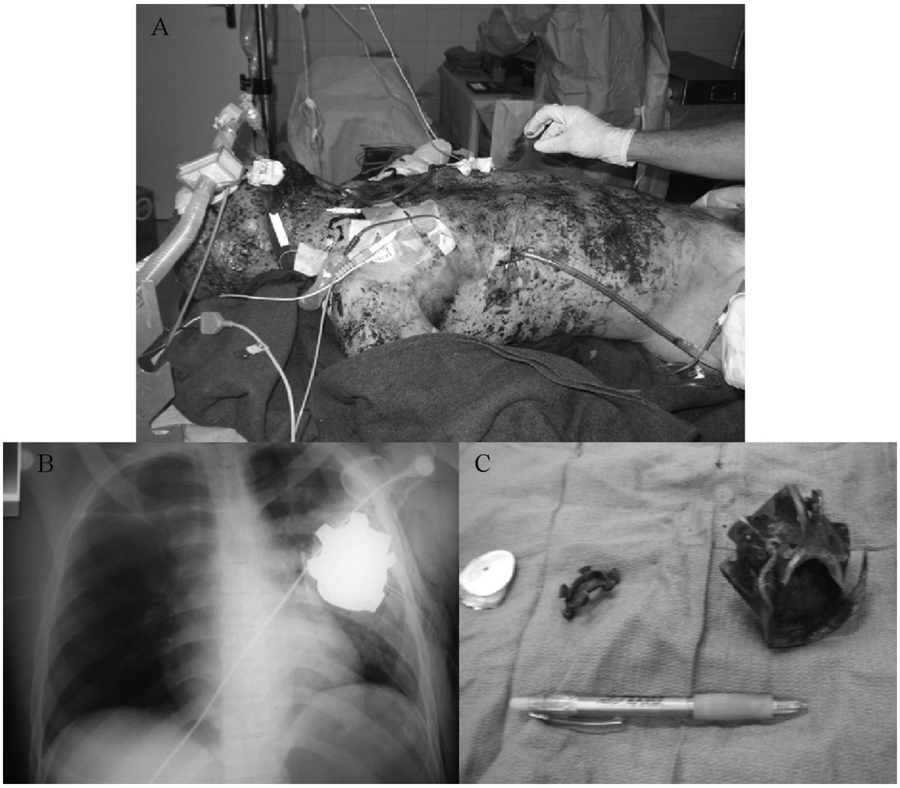

Figure 1. *A*, Polytrauma patient after suicide bombing. Neurosurgeons completed a craniotomy and the patient is being transferred to the intensive care unit for continued postoperative resuscitation. *B*, Chest x-ray of a patient with an intrathoracic foreign body; the patient survived successful removal of fragments (*C*).

Optimal intensive care is a significant aspect of the continuum of care for injured combatants and it is imperative to improving outcomes and survival of critically injured patients (Fig. 1).

Despite this imperative, no study had evaluated the effect of critical care organizational differences for a CSH during war operations or in situations of operations other than war. Mortality is likely multifactorial, but after prompt surgical therapy, intensive care unit management may have the greatest impact. Researchers subsequently analyzed their experience in Iraq to determine whether there are significant mortality differences, decreased length of stay, and resource utilization as a function the organizational characteristics of the intensive care unit in a CSH.

Rotations of noncritical care-trained and intensive care providers at the 31st and 86th CSH in January 2004 to May 2005, in support of OIF, provided a unique opportunity to review outcomes from three different intensive care unit staffing and organizational models. The authors retrospectively reviewed data from the joint theater trauma registry and evaluated those intensive care unit patients with known outcomes (n = 730). The models included a) CSH without trained intensivist (n = 62); b) CSH with consultant intensivist (n = 441); and c) CSH with intensivist-directed intensive care unit team (IDT) (n = 197) (team included critical care physician, staff surgeon, rotating internist, nurses, respiratory therapist, microbiologist, radiologist, and various subspecialty surgeons) (Fig. 2). The primary outcome was mortality and secondary outcomes included length of intensive care unit stay. Figure 3 displays the mechanisms of injury. There were no differences in the admission physiological, laboratory data, or blood products administered (Table 3). Intensive care unit mortality decreased from 25.8% (16 of 62) to 14.4% (68 of 471) (p = .021) when an intensive care unit consultant was used. The implementation of an IDT further reduced mortality to 10.1% (20 of 197) (p = .002). When mortality in the consultant model is compared with the IDT, there is a trend toward statistical significance (p = .067). This represents a 30% relative reduction in mortality. The average length of stay in the intensive care unit decreased from 8 ± 9.5 days to 6 ± 8.5 days ($p = .072$) with intensivist consultant and 5 ± 7.1 days ($p = .017$) in the IDT model (Fig. 4).

There are significant limitations in these data related mostly to combat casualty care follow-up, particularly from host nation casualties, although several other researchers have also found significant differences in intensive care unit mortality related to organizational characteristics of the CSH both in Iraq and Afghanistan (MAJ Craig McFarland, MD, MAJ Jeffrey Musser, MD, and MAJ Christopher J Lettieri, MD, personal communication). This also documents that even in variable austere environments ranging from Afghanistan to multiple locations in Iraq that the application of critical care fundamentals can improve outcomes. Moreover, the recent findings of a 32% reduction in mortality by intensivist-directed teams over that of pulmonary consultation alone in a common critical illness syndrome, ARDS, supports this model when organizing the intensive care unit to manage cohorts of severe polytrauma patients (34).

Figure 2. Afternoon multidisciplinary rounds at the 31st combat support hospital (CSH) intensive care unit, Baghdad, Iraq. The CSH occupies a Baath Party hospital located in the International Zone (Green Zone). This is a partial collection of the team, including LTC Lorne Blackbourne, MD (trauma/critical care surgeon), MAJ Alec Beekley, MD (general surgeon), MAJ Jeremy Perkins, MD (hematologist/oncologist deployed as an internist), and LTC Kurt W. Grathwohl, MD (anesthesiologist/pulmonary/critical care, deployed as a neuroanesthesia provider while also assuming medical directorship of the intensive care unit).

The mechanisms that result in decreased mortality when intensive care units are directed by an intensivist are likely multifactorial (34). Specifically, in severe polytrauma patients cared for in the CSH, intensivists assume an increasingly important role that is evolving with changes in surgical management. One of the changing surgical approaches is the concept of damage control surgery. Damage control operations are performed immediately on polytrauma casualties to stop and control hemorrhage as well as isolate potential sources of contamination. The exploratory laparotomies/thoracotomies or external fixation of orthopedic injuries typically last less than 1 hr and patients are transported with open abdomens and wounds to the intensive care unit. Continued resuscitation, including rewarming, correction of coagulopathy, treatment of ongoing hemorrhage, hemodynamic support, mechanical ventilation, and avoidance of resuscitation injury, occurs in the intensive care unit until the patient is re-explored and receives more definitive surgical therapy. Surgeons commonly operate for extended hours during mass casualty incidents, on multiple patients, which often preclude their presence at the bedside during ongoing resuscitation. As a result, the intensive care unit physician and team must continually re-examine the patients as part of the tertiary survey to identify any missed injuries as well as provide thoughtful resuscitation to appropriate end points, providing organ-specific support, controlling pain, and modulating the inflammatory response. These interventions, adherence to evidence-based practices, and clinical practice guidelines are important to avoid iatrogenic complications such as abdominal compartment syndrome associated with overresuscitation, deep venous thrombosis, ventilator-associated pneumonia, catheter-related bloodstream infections, renal failure, and wound infections. In fact, one group found that ventilator-associated pneumonia rates in an Afghanistan CSH decreased from 44% to 8% ($p < .001$) when an intensivist-model intensive care unit was implemented (MAJ Christopher Lettieri, MD, personal communication). Needless to say, in the CSH, attention to these practices, liberation from mechanical ventilator protocols, and vigilance ultimately decrease ventilator days and intensive care unit length of stay, thereby improving resource use.

Amazingly, the tools and skills to perform these functions rely little on bulky or highly technologic equipment, but rather on well-trained multidisciplinary teams (4, 5, 33). The high acuity and numbers of potential lives saved makes the organizational characteristics of the intensive care unit an important factor in the continued development of a joint Iraqi and Afghanistan theater trauma system (33). As a result of these findings and concepts, intensivists now deploy to the busiest CSHs in Iraq to develop and direct intensive care unit teams. Additionally, the U.S. Army has included two intensivists in the organizational models of the

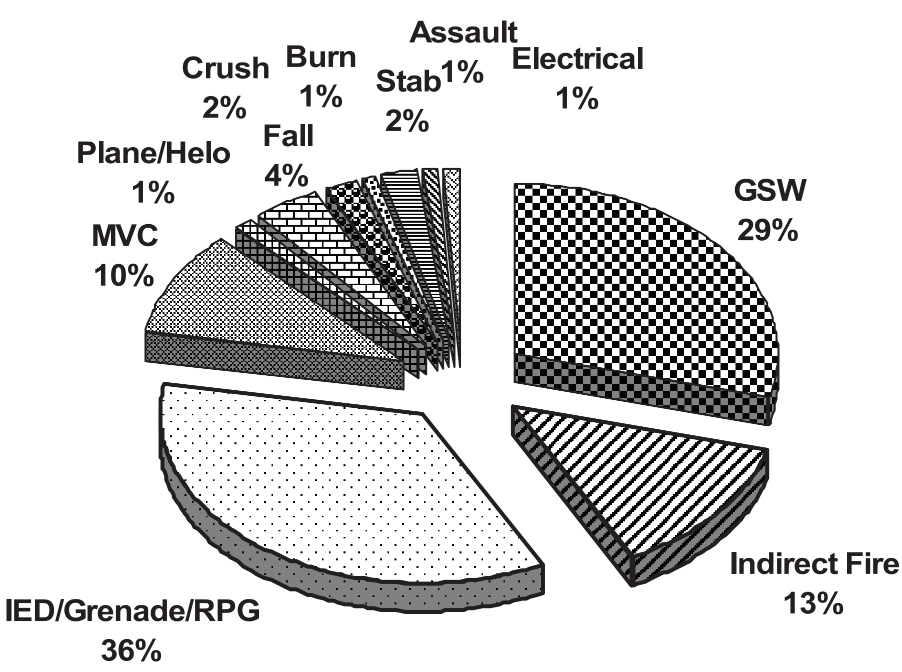

Figure 3. Mechanisms of injury: motor vehicle crash (*MVC*); plane/helicopter accident (*Plane/Helo*); improvised explosionary device (*IED*); rocket-propelled grenade (*RPG*); and gunshot wound (*GSW*).

Table 3. Admission demographic, physiologic, and laboratory data

	No Intensivist (n = 62)	Intensivist Consultation (n = 471)	IDT (n = 197)
M	62 (0)	441 (93)	188 (95)
F	0	30 (7)	11 (5)
Am/Coal	14 (5)	26 (5)	6 (3)
Iraqi	74 (95)	445 (95)	191 (97)
Avg Age	35.6 ± 13.2	29.2 ± 13.5	28 ± 13.6
SBP	117 ± 23	118 ± 26	124 ± 27
HR	114 ± 24	106 ± 26	101 ± 27
Temp	98 ± 2	96.7 ± 6.7	96.9 ± 2.4
GCS	14 ± 2	13 ± 7	13 ± 4
HCT	34.9 ± 8.9	35.9 ± 8.7	35.2 ± 8.3
pH	7.2 ± .13	7.27 ± .13	7.3 ± .11
OR	53 (85)	390 (82)	167 (85)
PRBC	2.5 ± 3.6	3.0 ± 4.3	3.3 ± 5.3
FFP	0.38 ± 3.6	1.4 ± 2.9	2.1 ± 5.0
WB	0.05 ± 0.21	0.13 ± .77	0.6 ± 2.3
		p = NS	

M, male; F, female; Am/Coal, American/Coalition; Avg, average; SBP, systolic blood pressure; HR, heart rate; Temp, temperature; GCS, Glascow Coma Scale; HCT, Hematocrit; OR, operating room; PRBC, packed red blood cells; FFP, Fresh Frozen Plasma; WB, whole blood; NS; non-significant; IDT, intensivist-directed team.

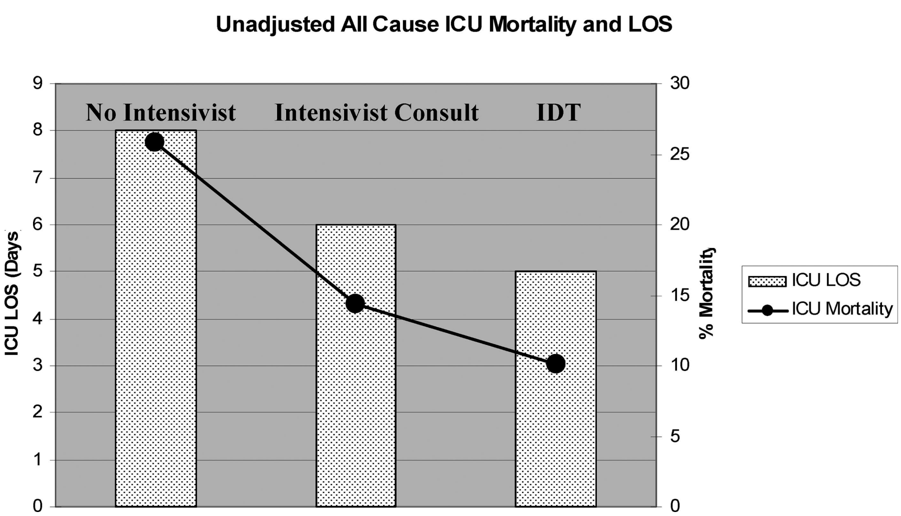

Figure 4. Operation Iraqi Freedom 31st and 86th combat support hospital January 2004 to May 2005. *ICU*, intensive care unit; *IDT*, intensivist-directed team; *LOS*, length of stay.

Figure 5. Remote presence technology allows intensivists to project their expertise to locations worldwide.

future medical re-engineering initiative CSH, which will deploy in 2010. The medical re-engineering initiative CSH will replace the field and general hospitals and is designed to meet the needs of rapid and strategic deployment under ambiguous conditions. This platform may be useful for similar civilian deployments to meet the needs of future forecasted catastrophic national disasters in the United States.

Despite a rapidly mobile critical care platform, the U.S. military is unfortunately faced with similar civilian shortages of critical care physicians and nurses to staff extended worldwide missions (2, 4). Realizing this shortfall, the U.S. Army has developed short- and long-term plans to prepare for contingencies to meet shortages and provide critical care services in the CSH and austere environment. First, the U.S. Army identified medical subspecialists such as cardiologists and nephrologists who have experience in the management of critically ill patients and teamed them up with critical care-trained physicians to deploy as intensive care unit augmentees. Second, the Army is working on developing training courses for physicians, nurses, and medical technicians to teach the fundamentals of critical care. The course would be similar to the SCCM's Fundamental Critical Care Support course but be more comprehensive and include clinical experiences. This concept is similar to the U.S. Air Force CCATT training courses, which include a 2-wk comprehensive training program and then an additional 2-wk training at a civilian level I trauma hospital known as the Center for Sustainment of Trauma Readiness Skills (4). The U.S. Army, U.S. Navy, and U.S. Air Force currently also have similar trauma training courses for retraining, skill teaching, and team building for FSTs at various large level I trauma centers throughout the country. These courses are not designed for nonsurgeons but specifically the management of postoperative critically ill polytrauma patients and would need to be adapted. The SCCM is also currently developing a course entitled Hospital Mass-Casualty Disaster Management to teach augmentees the skills necessary to work in the intensive care unit. The U.S. Army is also developing the role for remote presence technology to project the expertise of a limited number of intensivists and subspecialists worldwide (Fig. 5). Future plans include the development of a critical care network that links the critical specialist, subspecialist, and multidisciplinary critical care teams scattered all over the world (Fig. 6). This project will help implement and standardize best critical care practices as well as capture critical care data worldwide from multiple institutions. This will allow the military to track current prac-

Figure 6. Logo for Army Critical Care Network.

Figure 7. MAJ Jeremy Perkins (hematologist/oncologist) deployed as an internist to the 31st combat support hospital and working as part of the multidisciplinary critical team under the supervision of an intensivist performs diagnostic portable bedside echocardiography.

tices and outcomes, identify trends, and develop innovative therapies.

CONCLUSIONS

Intensive care has and will be required in the case of terrorist attacks, natural disasters, widespread infectious epidemics, and other large-scale catastrophes. Previous experience has proven and shortages of clinicians trained in critical care illuminate the lack of adequate preparation in the United States to provide mass critical care on a federal, state, or local level (6). One of the major perceived limitations to mass critical care is the time required to deploy and set up outside of fixed hospital facilities. Another perception is critical care, because it is intensive, uses significant resources, is logistically difficult, and dependent on technologically advanced equipment. The evolution of critical care organizationally in the U.S. military over the last decade and more recently the last 6 yrs has clearly demonstrated several important lessons that can be used to improve the current NDMS. Our experiences managing thousands of critically ill patients in worldwide austere locations, including in the air, has proven that sophisticated critical care with available portable technology can be achieved (Fig. 7) (4, 5). Rather than associate the equipment and technology with critical care, intensive care should imply the vigilant attention of a skilled multidisciplinary team. Additionally, critical care physicians and a multidisciplinary team must be additive to surgeons who are commonly occupied in the operating room. Others have suggested and we have demonstrated that trained intensivists can supervise and collaborate with other physicians, physician assistants, nurse practitioners, and other healthcare providers to manage many critically ill patients (2, 6, 33). Ideally, nonintensivists and other healthcare providers should periodically retrain in critical care practices to facilitate unexpected large amounts of casualties (6). Therefore, developing augmentee training courses and certification for healthcare providers who have experience in critical care but work in noncritical care areas on a daily basis is necessary. Planners should also continue to explore remote presence and electronic intensive care unit concepts that can project intensivists to multiple locations worldwide or austere locations. Finally, the NDMS should develop levels of care with mobile and flexible modular structures to provide emergent and graded responses as well as multidisciplinary critical care assets when required (8).

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