Burn Support for Operation Iraqi Freedom and Related Operations, 2003 to 2004

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Thermal injury historically constitutes approximately 5% to 20% of conventional warfare casualties. This article reviews medical planning for burn care during war in Iraq and experience with burns during the war at the US Army Burn Center; aboard the USNS Comfort hospital ship; and at Combat Support Hospitals in Iraq and in Afghanistan. Two burn surgeons were deployed to the military hospital in Landstuhl, Germany, and to the Gulf Region to assist with triage and patient care. During March 2003 to May 2004, 109 burn casualties from the war have been hospitalized at the US Army Burn Center in San Antonio, Texas, and US Army Burn Flight Teams have moved 51 critically ill burn casualties to the Burn Center. Ten Iraqi burn patients underwent surgery and were hospitalized for up to 1 month aboard the Comfort, including six with massive wounds. Eighty-six burn casualties were hospitalized at the 28th Combat Support Hospital for up to 53 days. This experience highlights the importance of anticipating the burn care needs of both combatants and the local civilian population during war. (J Burn Care Rehabil 2005;26:151–161)

The US Army Institute of Surgical Research (ISR, the US Army Burn Center) has cared for all of the seriously burned US military casualties from Operations Iraqi Freedom (OIF), Enduring Freedom (OEF), and the Global War on Terrorism. Most of these casualties originated from OIF. In addition, deployed US medical units, including the US Army Combat Support Hospitals (CSHs) and the US Navy hospital ship USNS Comfort, have provided both initial resuscitation of Coalition burn casualties and definitive care of a number of Iraqi and Afghani civilians and enemy prisoners of war with burns. This article provides an overview of the US military's preparations for war, experience during the war, and definitive care for both burned service members and local civilians. The Institutional Review Board approved this work.

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The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army, the Department of the Navy, or the Department of Defense.

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PLANNING FOR WAR

In preparation for possible war in Iraq, a planning team assembled at the ISR, examined several casualty scenarios, and developed strategies for these scenarios. The US Army Surgeon General directed the ISR to receive all US military burn casualties up to its maximum capacity, to receive any significant mustard agent casualties, and to continue to provide care to civilians with burns in the local region (South Texas) as in peacetime. The planning team assumed that approximately 10% of wartime casualties during OIF would involve thermal injury. Historically, burns

have constituted 5% to 20% of conventional warfare casualties. Burns are more common during wars at sea[1] and during wars involving armored fighting vehicles. They accounted for 10.5% of injuries sustained during the Yom Kippur War of 1973,[2] 8.6% during the Lebanon War of 1982,[3] and 7.9% during the first Gulf War.[4] Also, previous experience has suggested that approximately 80% of burns involve less than 20% TBSA, and are, per se, not life-threatening.[5]

The planning team built on experience during the first Gulf War of 1990 to 1991 (Operation Desert Storm).[5] For Desert Storm, with approximately 500,000 deployed troops, as many as 30,000 to 40,000 casualties, including 15,000 deaths, were projected in a worst-case scenario.[5] This would have yielded 15,000 to 25,000 treatable patients, of whom approximately 10%, or 1500 to 2500, would have burns. Twenty percent of this number, or 300 to 500 patients, would have burn sizes in excess of 20% and would require treatment in a burn center. For OIF, with half the number of deployed troops, a similar casualty rate would yield up to 250 casualties with major burns. Thus, it was necessary to enact, with modifications, the "three-dimensional" strategy developed for the first Gulf War, involving the ISR Burn Center, the American Burn Association, and deployed medical units.[5]

Recognizing that no single burn center could care for 250 intensive care unit (ICU) patients, a national response for burn care in the event of a mass casualty situation was developed, in collaboration with the American Burn Association and 70 participating burn centers across the country. This effort is detailed elsewhere in this issue of the *Journal* (ie, Barillo et al[6]). The possibility of activating the Burn Specialty Teams (BSTs) and Disaster Medical Assistance Teams (DMATs) to support the Army Burn Center also was discussed with the National Disaster Medical System. These teams were made available but fortunately were not required.

It was assumed that sulfur mustard agent would be used against Coalition forces during OIF. Recognizing certain similarities between mustard injuries, burns, and toxic epidermal necrolysis syndrome, a protocol for the care of mustard casualties was developed in conjunction with a sister laboratory of the ISR, the US Army Medical Research Institute of Chemical Defense, at Aberdeen Proving Ground, Maryland.[7] Topical antimicrobial treatment, depending on depth of injury and degree of contamination, would follow established burn center practices. Management of bone marrow suppression, if present, would include the early use of granulocyte colony-stimulating factor (Table 1).

A plan for aeromedical evacuation of burn casualties was instituted. The ISR's Burn Flight Teams have been in operation since 1951 and pioneered the aeromedical transport of seriously ill burn patients.[8–14] These teams embody the concept that full-time burn critical care personnel, with additional training and experience in aeromedical evacuation, are best suited to provide the highest quality of care possible during the transport of a critically ill burn patient. Each Burn Flight Team consists of a general surgeon, critical care registered nurse, licensed vocational nurse, and respiratory therapist from the burn ICU. Recently, a senior Noncommissioned Officer has been added to serve as the operations and logistics officer for transoceanic flights as well. To maintain the ability to deploy two full teams worldwide within 2 hours of ini-

Table 1. Elements of the joint United States Army Institute of Surgical Research–US Army Medical Research Institute of Chemical Defense protocol for the care of mustard agent casualties

Lungs
Primary cause of death: early airway obstruction; later pulmonary infection
Treatment similar to smoke inhalation injury in most respects
Fluid Resuscitation
Similar to TENS: fluid resuscitation may be needed, but less than following burn injury
Later: calculate water losses as for an open burn wound
Skin
Partial-thickness injury: blisters once unroofed may be treated with silver sulfadiazine, silver-impregnated dressings, or synthetic bilaminar skin substitutes
Deep or full-thickness skin necrosis: may be treated with alternating mafenide acetate and silver sulfadiazine creams
Marrow
A 50% decrease in lymphocyte count from initial presentation to 24–36 hr later indicates bone marrow suppression
Consider immediate use of granulocyte colony stimulating factor
Eyes
Corneal injury can occur; treat with antibiotics and possibly topical steroids

tial notification around the clock and throughout the year, it is necessary to assign a total of 20 personnel to Flight Team status.

In 1998, the applicability of the Burn Flight Team concept to a variety of other specialized medical missions was recognized by the US Army by the establishment of Special Medical Augmentation Response Teams (SMART teams), not only for burns, but also for emergency medicine, nuclear/biological/chemical response, stress management, pastoral care, preventive medicine, health systems assessment, veterinary medicine, telemedicine, and infectious diseases. These SMART teams are directed at both domestic and overseas mass casualty disasters, and the team role is to be advisory and augmentative in nature.[15] The concept of SMART Burn Teams providing limited assistance and expertise—rather than aeromedical evacuation—was tested after fire disasters in Guyana on December 18, 2000, and in Peru on December 29, 2001. Even so, most Burn Flight Team missions continued to focus on assessment, stabilization, and aeromedical evacuation of burn patients to the ISR. Both paradigms—training/augmentation and direct patient care/evacuation—were used during OIF.

In the 1990s, the US Air Force (USAF) adopted the Burn Flight Team model by establishing the Critical Care Air Transport Team (CCATT) program for the evacuation of patients without burn injuries.[16] In turn, the ISR's Burn Flight Teams became, during the year leading up to OIF, the only Army teams whose members were trained and certified through the USAF CCATT program. With the establishment of CCATT as the standard throughout the USAF for critical care evacuation, CCATT training for all Burn Flight Team members added greatly to their ability to interact on an equal professional standing with USAF personnel.

The use of Burn Flight Teams has evolved with each new conflict or mass casualty disaster to which the US Army has responded. During the Vietnam War (1967–1972), the Teams transported 824 burn patients from that conflict to the ISR.[17] These patients were transported from a general hospital especially designated as a burn casualty staging facility in Japan. Missions to recover these patients were made once every week or two. In 1989, the unit responded to a pipeline explosion in Ufa, Russia, with a team that was augmented by operating room, laboratory, and rehabilitation personnel.[18] During Operation Desert Storm, three ISR Burn Flight Teams were prepositioned in Saudi Arabia, and one burn surgeon Liaison Officer (LNO) was stationed at the US military hospital in Landstuhl, Germany, through which casualties flowed back to the United States. Experience during that conflict suggested that the deployed Burn Flight Teams were underused.[5] Because of this, and in view of current staffing levels at the ISR, full Burn Flight Teams were not prepositioned in the theater of operations for OIF. Rather, one LNO was placed in Kuwait and one was placed in Landstuhl. Both LNOs were experienced ISR burn surgeons. ISR Burn Flight Teams were then sent to Landstuhl, as needed, to bring back critically ill patients to the Burn Center. Criteria for determining the urgency of a given patient's evacuation and for identifying the level of resources required—Burn Flight Team, CCATT, or routine aeromedical staff—were established (Table 2).

WARTIME CARE: ISR FIELD OPERATIONS

The Army Burn Flight Team performed 18 flights to Germany and 2 to Washington, DC, between March 2003 and May 2004, transporting a total of 51 war-injured burn patients. No flight-related complications occurred. The typical mission was activated upon receipt of a seriously burned casualty at the hospital in Landstuhl by means of a telephone call to the ISR. On occasion, the team was activated based on information telephoned to the ISR by CSHs in Iraq. However, the Burn Flight Team did not have clearance to fly into the theater of operations; burn patients were flown out of Iraq to Landstuhl by CCAT teams, with additional Army manpower from the sending CSH if necessary. Burn Flight Team launch authority was delegated to the Commander, ISR. In general, the criteria for Burn Flight Team use (Table 2) were followed, except that the presence of multiple severe nonthermal injuries, in addition to burns, also was used as a criterion. In every case, aircraft availability dictated that the Flight Team travel to Germany by commercial aircraft and return to the Burn Center by USAF military aircraft. Procedures performed at Landstuhl by Burn Flight Team surgeons included escharotomies, fasciotomies, and amputations. New technology introduced by the Burn Flight Team during the war included a new device for mounting ventilators, monitors, and pumps to the NATO litter, the Special Medical Emergency Evacuation Device (ie, SMEED^{TM}) platform.[19]

The ISR LNO at Landstuhl (B.J.K.) was deployed on February 24, 2003 and returned on May 15, 2003. This surgeon was attached to the European Regional Medical Command; this allowed, importantly, for flexibility of action. In preparation for OIF, his roles included assessment of the burn-specific supply needs of the hospital at Landstuhl, provision of ABLS and CBLS training to approximately 160 pro-

Table 2. Burn patient aeromedical regulation

Burn severity definitions
Limited: <10% total body surface area (TBSA)
Moderate: 10–30% TBSA
Severe: >30% TBSA
Scenario 1
Limited partial thickness burns not involving hands, joint, face, perineum
Full healing expected in 2 weeks
Remain at Landstuhl for wound care with expected return to duty
Scenario 2
Limited partial thickness involving hands, joint, face, perineum, or any full-thickness burns
Full healing not expected in 2 weeks or special rehabilitation issues
Transfer to Institute of Surgical Research (ISR) routine air evacuation
Scenario 3
Moderate partial thickness or full thickness burns, patient stable
Full healing not expected in 2 weeks or special rehabilitation issues
Patient requires intubation for transport
Transfer to ISR using CCATT
Scenario 4
Severe partial-thickness or full-thickness burns or inhalation injury requiring intubation, patient stable
Full healing not expected in 2 weeks or special rehabilitation issues
Patient requires intubation for transport
Transfer to ISR using Burn SMART team
Scenario 5
Severe burns or inhalation injury, patient unstable for air evacuation to CONUS
Transfer to European Burn Center
Scenario 6
Vesicant casualties: air evacuation to ISR

USAISR, United States Army Institute of Surgical Research, *CCATT*, Critical Care Air Transport Team; *SMART*, Special Medical Augmentation Response Teams.

viders at Landstuhl and at US Navy Fleet Hospital 8 in Rota, Spain, and coordination with regional European burn centers. He performed site visits to German burn centers at Koblenz and Ludwigshaven. These centers, in addition to the Military Hospital Queen Astrid in Brussels, Belgium, were to be used for patients who were too unstable to move to the United States or in the event that US burn centers became filled to capacity. During OIF, the LNO cared for 36 burn patients and coordinated the transfer of 20 of these patients to the ISR burn center. He also served as LNO for nonthermally injured Special Operations casualties, caring for 83 such patients. Burn care in the Landstuhl ICU was facilitated by a reservist nurse who, as a civilian, had worked at the ISR.

Along with an ISR burn nurse, the ISR LNO in the Gulf region (L.C.C.) deployed in late February 2003, at the request of the Coalition Forces Land Component Command surgeon, Brigadier General George Weightman, to provide ABLS and CBLS training throughout Kuwait. Subsequently, this LNO's main responsibility was to serve as principal investigator for a hemostatic dressing Investigational New Drug protocol on the battlefield. It was not tactically feasible for this LNO to travel throughout the region to provide care on the ground for burn casualties. However, an influx of burn casualties to the USNS Comfort (see below) led to his providing care aboard that vessel. This LNO returned to the United States on June 1, 2003.

WARTIME CARE: ISR BURN CENTER OPERATIONS

The Army Burn Center admitted, between March 2003 and May 2004, a total of 109 patients with war-related burns. All of these were active duty service members except for four foreign national soldiers and one civilian employee of the US Department of Defense. The branch of service is given in Table 3. Two patients were injured in Djibouti, four in Afghanistan, and the rest in Iraq or Kuwait. A total of 18.3%, or 20 patients, had burns of greater than 20% TBSA. A total of 5.5%, or six patients, had smoke inhalation injury; four of these six patients had burn size in excess of 20%. The median total burn size was 8% (interquartile range, 12.2; range, 0.2–93.3), and

Table 3. Branch of service

Status	Frequency	Percent
U.S. Army	84	77.1
U.S. Marine Corps	14	12.8
U.S. Navy	3	2.8
U.S. Air Force	2	2.8
U.S. DOD Civilian	1	0.9
Foreign National*	4	3.7

* Members of a coalition military service.

the median full-thickness burn size was 0 (interquartile range, 1.0; range, 0.0–89.4; Figures 1 and 2). The mean age was 26.5 years ± 7.2 SD (range, 18.9–53.0); all but two patients were men. Concomitant eye injuries occurred in 8.3%, or 9 patients, and fractures or traumatic amputations occurred in 13.8%, or 15 patients. The median number of operations performed in these patients to date is 1.0 (interquartile range, 2.0; range, 0–15), including those required for acute wound closure as well as reconstruction. A total of 44%, or 48 patients, were managed nonoperatively; 29.4% underwent one operation; 11% underwent two operations, and 15.6% underwent three or more operations.

The etiology of injury is given in Table 4. Roughly 56%, or 61 cases, constituted preventable injuries, that is, were judged to be the result of accidents rather than hostile fire in the opinion of these authors. Thus, for example, the burning of human waste or other refuse with accelerants was the most common cause of injury among these service members, occurring in 22% or 24 patients. Concerns about this finding were transmitted to in-theater preventive medicine personnel in late 2003, after which a decrease in the number

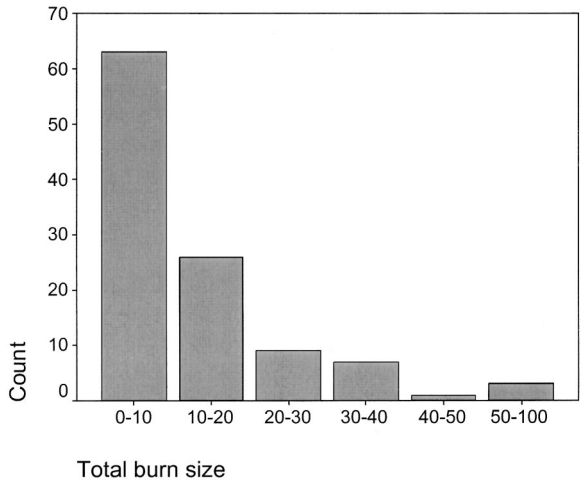

Figure 1. Total burn size distribution.

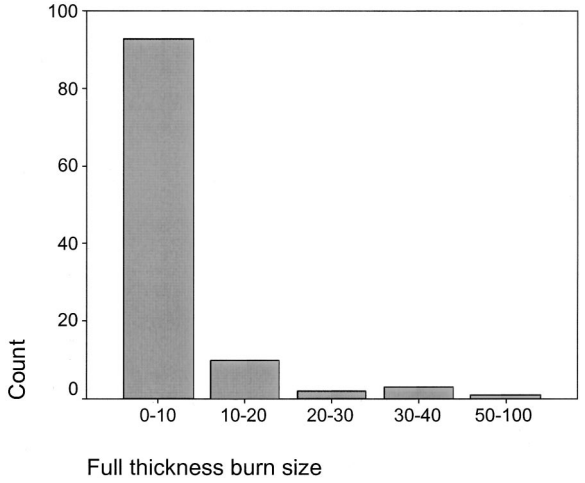

Figure 2. Full-thickness burn size distribution.

Table 4. Cause of injury

Event	Frequency	Percent
Burning trash or human waste	24	22.0
Handling ordnance or gunpowder	17	15.6
Other missile or bomb	14	12.8
Rocket propelled grenade	11	10.1
Other fuel/gasoline handling incident	8	7.3
Electrical	6	5.5
Other	6	5.5
Friendly fire accident, including misfires	4	3.7
Building or chemical plant fire or explosion	4	3.7
IED	4	3.7
Scald	3	2.8
Motor vehicle accident	3	2.8
Aviation accident	2	1.8
Vehicle hit land mine	2	1.8
Chemical	1	0.9

IED, improvised explosive device.

of such accidents was observed. Accidents involving the handling of ordnance, gunpowder, or fuel constituted other leading causes.

Admissions of wartime casualties to the Burn Center, to date, have peaked twice; once in April 2003 after the onset of hostilities, and once in April 2004 during a period of insurgency (Figure 3). As a consequence of the war, admissions to the Burn Center (including civilians and military) increased from 18.6 ± 4.4 SD for May 2002 to February 2003 to 29.1 ± 4.8 SD for March 2003 to April 2004 (Figure 4). During the height of OIF (May 2003), a maximum of nine beds were occupied in the two burn ICUs at the ISR in addition to burn ward. Mean daily census, including ICU and ward patients, peaked in Septem-

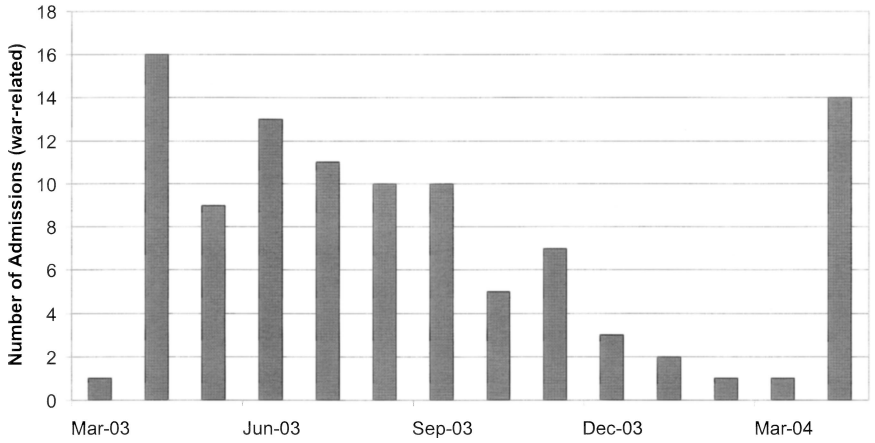

Figure 3. Monthly war-related burn admissions. Admissions to the Army Burn Center peaked in April 2003 and again in April 2004.

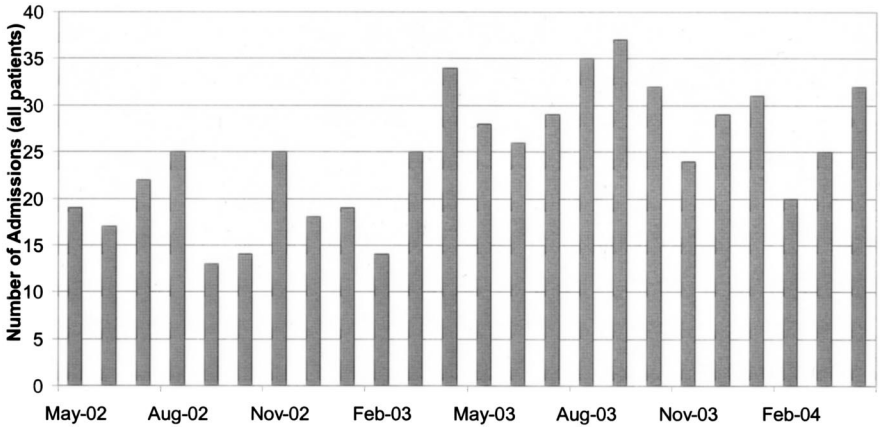

Figure 4. Impact of the war on monthly admissions. Admissions to the Army Burn Center increased from a mean of 18.6 patients per month before the war to 29.1 per month after the war began.

ber 2003 (Figure 5). Nursing staffing at the beginning of OIF in March 2003 included, for the burn ICU, 22 registered nurses and 20 licensed vocational nurses, and for the burn ward, 6 registered nurses and 16 licensed vocational nurses. These numbers include military and civilian employees and contractors. In addition, the increased workload mandated the activation of reservists with the 5501st Army Hospital, including four critical care registered nurses, one ward nurse, and one licensed vocational nurse. One experienced burn surgeon, an ISR alumnus in the US Army Reserves (D.J.B.), was activated to backfill the Gulf region LNO during the latter's deployment.

ISR adhered to its previously described infection control practices in the care of the OIF casualties.[20] Surveillance cultures of wounds, sputum, urine, and stool were obtained on admission and three times a week throughout the hospital stay to detect and track the presence of multiple-drug-resistant organisms. In the burn ICU, special precautions (isolation) were used for all patients. On April 9, 2003, one OIF burn patient was admitted who was then noted to be colonized with multiple-drug-resistant *Acinetobacter baumannii*. Data were soon obtained from Landstuhl, the USNS Comfort, and other medical centers indicating that resistant *A. baumannii* was commonly found in OIF casualties. As a consequence of these findings, and during an influx of a large number of OIF casualties, the ISR's second burn ICU was opened on April 24, 2003, as an isolation unit for infection control purposes. Subsequent OIF casualties were admitted directly to, and stayed within, the second burn ICU until it was no longer needed and was closed on May 13, 2003. Thereafter, OIF casualties were kept in special precautions isolation until three successive sets of surveillance cultures returned negative for multiple-drug-resistant organisms. A total of 24 burned service members (22.6%) were ad-

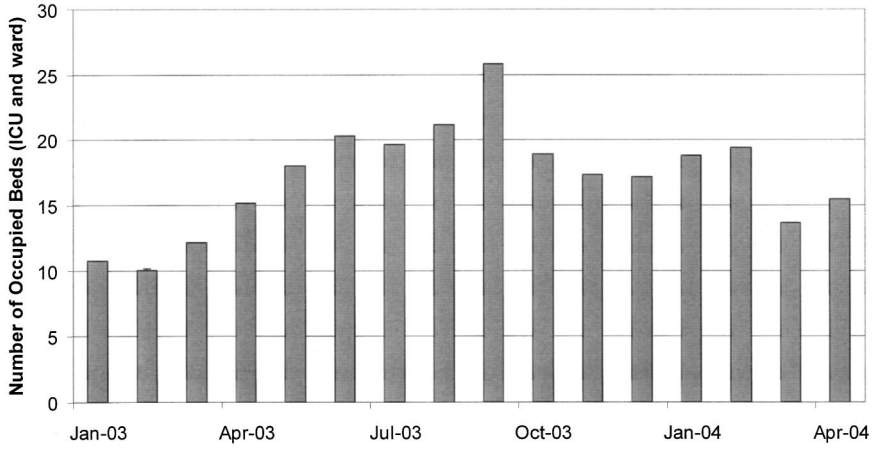

Figure 5. Mean daily census. The mean daily census peaked in September 2003 at the Army Burn Center, several months after the peak influx of war-related patients.

mitted with *A. baumannii* colonization or infection. On the basis of antibiotic sensitivity pattern analysis, this enhanced isolation protocol succeeded in preventing the horizontal transmission of *A. baumannii* to all but two other burn patients; these events occurred in October 2003, after the second ICU closed. However, at a census of eight to nine patients distributed between two separate ICUs, nursing staffing levels were somewhat strained.

Psychological problems are a frequent component of the response to burn injury. Recognizing this, the Psychiatric Clinical Nurse Specialist for the Army Burn Center, a licensed independent practitioner with limited prescriptive authority, screened every burn casualty from the conflict upon admission and provided treatment and follow-up as needed. A preliminary analysis of the first 38 burn casualties from OIF, admitted between March 5, 2003, and June 21, 2003, identified 44.7%, or 17 patients, with core symptoms of anxiety, 26.3%, or 10 patients, with core symptoms of depression, 5 patients with body image disturbance, 4 with delirium, and 3 with significant anger. A total of 31.6%, or 12 patients, received medications for treatment of anxiety or affective symptoms. By multivariate logistic regression analysis, the presence of symptoms of anxiety was predicted by hospitalization in the ICU and by the presence of hand burns. The presence of affective symptoms was predicted by amputation and by eye injury. No relationship was found between either anxiety or affective symptoms and the burn size, the relationship of the injury to hostile action, or its preventability. After discharge, patients with psychological symptoms were referred to mental health services at their home base. In addition, discharged burn patients were followed for up to 1 year and were screened for psychological problems during their clinic visits. Over the course of time, post-traumatic stress disorder has been diagnosed in a number of these patients. The true incidence of post-traumatic stress disorder after combat burn injury and how best to prevent or treat it remain important, unresolved questions.

Burned service members received a variety of services at the Burn Center. A privately funded program, the Fisher House Foundation, provided families with free lodging near the hospital. Soldiers were supported by events such as award ceremonies and visits by military leaders and dignitaries. In the opinion of the authors, having the burned service members at one location facilitated this type of support and also likely had intangible benefits from a morale standpoint.

As of May 2004, most patients (67.9%, or 74 active duty patients) had returned to duty, most with limited duty profiles for the first year after their burn injury. A total of 18.3%, or 20 patients, were still hospitalized or had been released for convalescent leave. A total of 11.9%, or 13 patients, had undergone or were in the process of undergoing a Medical Evaluation Board for probable separation from the service. To assist soldiers with the separation process, two full-time representatives of the Veteran's Administration were stationed at the hospital and counseled all of the casualties.

WARTIME OPERATIONS: CARE OF LOCAL PATIENTS

Because of the resource-intensive nature of burn care, US military doctrine recommends against providing

definitive burn care within the theater of operations.[21] However, it was necessary for deployed US medical units, and other Coalition medical units, to provide such care to a number of Iraqi civilians and enemy prisoners of war (EPWs) during OIF. This care was provided at various locations, including several CSHs and the USNS Comfort hospital ship.

The 28th CSH deployed to Iraq via Kuwait in March 2003 and returned home in February 2004. From April 11, 2003, to August 26, 2003, the 28th CSH operated in tents from an austere logistics base with a basic deployment stock. During this period, the CSH admitted 1867 patients. The CSH was designated as the primary in-theater burn facility. Burn injury constituted 86 admissions, or 5% of the total admissions, and 17 outpatient visits. Of the inpatients, 42 were US or Coalition service members and 44 were EPWs or civilians. The mean length of stay for service members was 2 days (range, 1–4); for EPWs or civilians it was 10 days (range, 1–53). One service member and seven Iraqis with burns died of wounds at the CSH, either almost immediately (with massive injury) or after 1 to 2 weeks in hospital (with infection or pulmonary embolus). Eighteen Iraqis were eventually transferred to civilian hospitals in Iraq, and five were transferred to burn centers in third countries in the region. Of the 877 total operations performed at the CSH, 59 were related to burn injury, including 49 wound débridements, 5 split-thickness skin graftings, and 4 escharotomies. In addition, a large number of conscious sedation procedures, performed by nurses trained by the CSH anesthesiologist, enabled wound care at the bedside. The burn patients were cared for in a specific tent designated as the "burn center" (Figure 6). Performance of this demanding mission was aided by the presence at the CSH of a former ISR burn nurse. The experience at the 28th CSH indicated that burns, although comprising only 5% of the inpatient numbers, constituted a much greater proportion of the inpatient workload. Significant challenges were noted with respect to the availability of burn-specific equipment, supplies, training, and knowledge.

The US military also provided civilian burn care in Afghanistan. The 452d CSH was deployed to Bagram Airbase, 47 km north of Kabul, where it provided care to Afghanis with life-, limb-, or eyesight-threatening conditions. During the 3-month deployment of one of the authors (M.M.B., June 1, 2003, to August 31, 2003), this CSH cared for 10 Afghanis with burns, and 8 with complex wounds secondary to injuries caused by land mines. Eight of the 10 burn patients were younger than 12 years of age. Silver nylon dressings[22] (Silverlon®, Argentum Medical LLC, Chicago, IL) were used, possibly for the first time in a field military setting. Silverlon® was left in place from 3 to 7 days at a time and was reused for a total application time of 7 days. Use of the dressing in this manner, in comparison with twice-daily dressing changes with silver sulfadiazine, appeared to decrease the total workload associated with burn wound care. There were no episodes of cellulitis or invasive burn wound infection associated with the use of Silverlon®. Fifteen burn-related operations were performed, in-

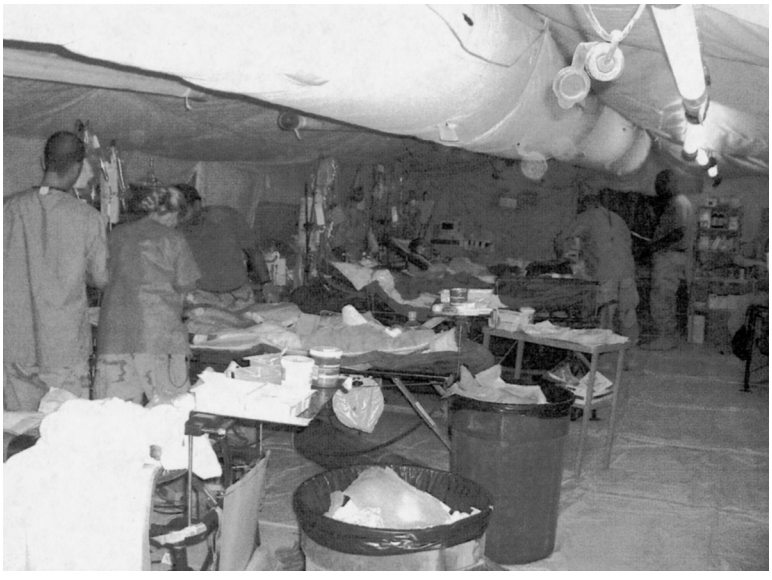

Figure 6. Burn care tent at the 28th Combat Support Hospital, Iraq.

cluding a rotational flap for a deep foot burn. There was one death, which occurred in a 14-month-old boy presenting with invasive burn wound infection 3 weeks after sustaining a 40% TBSA burn.

The USNS Comfort is a converted tanker, one of two hospital ships in the US Navy. It was positioned in the Persian Gulf before hostilities in Iraq. During OIF, it received a large number of civilian, EPWs, and Coalition casualties. One open-bay ICU was used for both burn and pediatric intensive care (Figure 7). Burn care was supervised by a burn-experienced plastic surgeon and ISR alumna (T.M.B.), with additional support during the peak influx of patients by the previously deployed ISR surgeon LNO in the region. In general, nurses and therapists providing burn care lacked significant previous burn experience, although several had received CBLS training at the ISR. The burn surgeons provided hands-on training for these personnel in wound care and other bedside procedures. Routinely stocked silver sulfadiazine cream and specially ordered mafenide acetate cream were used topically. Invasive gram-negative burn wound infection was definitively treated by clysis with the available antipseudomonal penicillin (ticarcillin), followed by excision to fascia.[20] Temporary wound closure was achieved using shelf-stable cadaver allograft (GammaGraft™, Promethean LifeSciences, Inc., Pittsburgh, PA). Intravenous ketamine was used generously to permit aggressive, surgeon-directed, twice-daily wound care at the bedside.

Ten Iraqi burn patients required surgery. These included four with burns of less than 20%, and six with larger burns. The former group responded well to traditional excision and autografting techniques and experienced an unremarkable hospital course. For the latter group, the mean burn size was 46.7% (range, 27–69%), and mean age was 23.7 years (range, 4–45 years). The cause of injury was non-combat-related house fires in four, and was unknown but possibly related to combat in two. They were injured during April 2 to 9, 2003, were initially stabilized in Coalition field hospitals, and were then transported to the Comfort by helicopter between 2 and 8 days after their burn injury (mean, 4.8 days). Of these six patients, three were hemodynamically unstable upon admission; three developed invasive gram-negative burn-wound infection; two required abdominal procedures (one for mesenteric ischemia, one for acalculous cholecystitis); one presented with suppurative thrombophlebitis; two were diagnosed with pneumonia; and all had one or more episodes of bacteremia, to include gram-negative bacteremia in all cases. Infection with multiple-drug resistant *Acinetobacter* was common, occurring in five of these patients. At the referring field hospital and on the Comfort, excision and autografting was performed four times in three patients, all with extensive graft loss. By contrast, five subsequently underwent excision to fascia and placement of gamma-irradiated allograft, all with good results. As the ship prepared to return to the United States, all six patients were transferred to Gulf region burn centers on May 5 to 6, 2003, after approximately 1 month on board; they were lost to follow-up.

Figure 7. Burn intensive care unit aboard the United States Naval Ship Comfort.

Observations about the USNS Comfort experience included the following: During war, civilian health care, to include burn care for patients of all ages, may temporarily become the responsibility of the occupying forces. The physical plant of the hospital ship, although superior to that of field hospitals, was not optimal for long-term care of burn patients: isolation of patients with multiple-drug resistant organisms was not possible, hypothermia was difficult to prevent, and hospital beds were not ideal for prevention of pressure sores. The logistical support of this forward-deployed ship was extraordinarily effective, such that nonstandard products, including gamma-irradiated allograft and mafenide acetate cream, were delivered within approximately 3 days of request. We recommend that such burn-specific products be prepositioned aboard ships for future conflicts of this nature. In particular, allograft was indispensable to the successful management of these patients, in whom grossly contaminated wounds precluded immediate autografting.

CONCLUSION

Burn care is a complex, resource-intensive, multidisciplinary team process that can be provided to the current standard of care only in centralized burn centers. In addition, service members injured during war have additional administrative, psychological, and emotional needs, facilitated by treatment in a military facility. Fortunately, the number of casualties received at the Army Burn Center during OIF taxed, but did not overwhelm, its ability to care for these patients. In a true mass casualty situation, however, a system was in place to assist in the logical regulation of burn casualties to open civilian burn beds across the country, as described elsewhere in this issue of the *Journal.*

The ability to deploy Burn Flight Teams within hours of initial notification to move critically ill burn patients from Landstuhl to Texas represented a paradigm shift toward more rapid Team deployment than was used, for example, during the Vietnam War. Such rapid deployment made it possible to retrieve patients before infectious complications or organ failure ensued while making it unnecessary to preposition Teams within Iraq. CCATT training through the USAF gave the Burn Flight Teams additional expertise and professional recognition that facilitated their interaction with their USAF colleagues.

Definitive care of patients with serious burns within the theater of operations is proscribed by current military doctrine. Nevertheless, experience at deployed medical units, including the CSHs and the USNS Comfort hospital ship, underscored the importance of planning for the care of civilians of all ages and EPWs with burns during and after combat operations. Burn care occupied a significant portion of the workload at these facilities, far in excess of the actual number of burn patients treated. Significant logistical challenges in the field, with respect to burn-specific supplies and equipment, were addressed with variable degrees of success.

The ability of a small number of burn specialists to impact a deployed hospital's burn care mission was demonstrated aboard the USNS Comfort. Aside from that experience, the current administrative status of the Burn Flight Teams did not permit their rapid deployment into the combat theater of operations. On the other hand, more than one thousand military personnel were trained in the basics of burn care in a very short period of time by ISR training teams at the Burn Center, in Europe, and in Kuwait, as discussed elsewhere in the *Journal.* The authors hope that this description of preparations for and experience during OIF and related operations will be helpful to medical planners during future conflicts.

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