Innovations in Caring for a Large Burn in the Iraq War Zone

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The authors report on a single case of a large, civilian burn cared for at a U.S. military hospital during Operation Iraqi Freedom. The management of the patient, using a large negative pressure wound therapy device and the Meek grafting technique, is reviewed. This is a case report. The patient survived his injury. In Iraq, most patients with this severity of injury succumb to the injury. By using two innovative techniques, the authors found that the patient was able to survive his injury and return to his home. (J Burn Care Res 2010;31: 665–669)

Since the beginning of Operation Iraqi Freedom, U.S. military and coalition forces who suffer burn injuries significant enough to require in-patient treatment are evacuated to established burn centers either in Europe or in the Continental United States. However, host nationals suffering burn injuries are either treated at local host nation facilities, or they may be treated at an established U.S. military hospital in the theater of operations. The latter has become more commonplace because the operation has changed to more of a humanitarian effort.

In the United States, large burns are becoming less common. However, it is not unusual for very large burns to be treated aggressively at any of the burn centers in the United States. Mortality rates have decreased over the past several decades; currently, approximately 95% of patients admitted to burn centers in the United States ultimately survive their injuries. The reasons for declining mortality are multiple. They include improved critical care, early excision and grafting, improved control and treatment of sepsis, and better understanding and use of nutritional support. Large burn wounds can be excised early and covered with homograft, allowing for piecemeal grafting over longer periods of time. In addition, cultured epithelial autografts (CEA) have enhanced the survivability of very large burns by providing a means with which to cover large wound area in both children and adults. Currently, most burn units are able to discharge patients in a timely manner, with many reporting stays as short as <1 day per percentage of BSA burned.

Unfortunately, in the current conditions in Iraq, large burns, particularly those >50% TBSA are almost uniformly fatal, and these injuries are often managed expectantly. This is due, in large part, to the inability to cover large wound areas with homograft or CEA, which leads to frequent and often severe infections. The facilities in use are suboptimal for long-term care. Sanitary bathing and shower facilities are lacking, thus making wound care problematic. The patients must be taken to the operating room (OR) on a daily basis for access to a clean environment and sterile wound care equipment. Tap water, although safe for healthy individuals to bathe with, is unsanitary to the immunocompromised and would undoubtedly lead to more infections if used routinely for wound care.

With limited resources, daily trips to the OR and availability of large quantities of dressing supplies as well as the personnel to use them are not realistic, making the care of a patient with a large burn difficult, if not impossible, in the current Iraqi healthcare system.

The mortality data, in host nation facilities, are in stark contrast when compared with burns occurring and treated in the United States. Recent data from the American Burn Association suggest that in patients who sustained a burn of 50 to 59.9% TBSA, the overall mortality rate was 38.4%. However, in the age group of our patients (20–29.9 years), the mortality rate was only 19.4%.[1] Thus, in North America, even

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large to very large burns are survivable with a relatively low mortality rate.

Over the past decade, a surge in wound care products has been noted. Today, there are dozens of wound care products and dressings in use on a daily basis in both burn and complex/chronic wound care settings. Of particular importance are the newer silver dressings and delivery systems.

Perhaps one of the most innovative and significant products on the market is the negative pressure therapy device. In 1995, Kinetic Concepts, Inc. (San Antonio, TX) released their prototype of negative pressure wound therapy known as the wound vacuum-assisted closure or wound VAC (WVAC). This device has changed the face of acute and chronic wound care.

The WVAC has been used extensively in complex wounds resulting from combat trauma in both Iraq and Afghanistan. WVAC pumps are widely available in both theaters of operation. The WVAC is being used more frequently in the burn wound setting.[2] It has been successfully used in partial thickness burn wounds and as a bolster for wounds requiring a skin graft. The ability of the WVAC system to protect the wound from the outside environment, control fluid drainage inherent of wounds, and stimulate growth of healthy tissue makes it a unique and useful in the armamentarium of the burn surgeon.

In addition, we chose to graft a portion of the patient's wound using the Meek technique. This technique involves the "mincing" of donor skin, which allows improved coverage area when adequate donor skin is lacking. We believe that the combination of the WVAC and the Meek technique contributed to the long-term and successful salvage of a host national with a very large (54% TBSA) burn under austere conditions.

CASE HISTORY

A 25-year-old host nation civilian with a BSA of 2.04 m^2 suffered a flash burn to approximately 54% TBSA after a propane tank explosion. He was flown via military medical helicopter to our facility. On arrival, he was able to speak and give an accurate history via an interpreter. However, he was noted to have extensive facial burns and began developing stridor and hoarseness. Therefore, he was expeditiously intubated. At the time of presentation, the patient was approximately 5 hours postburn and had received 3 L of intravenous fluids. His initial base deficit was −8. Fluid resuscitation was initiated, and the patient was taken to the OR for initial wound care.

In the OR, all wounds were thoroughly assessed, and he was calculated to have 54% total body surface area burned (TBSAB), all of which was deemed full thickness. Burn injury was present on the face, neck, anterior chest, abdomen, both hands and wrists (volar and dorsal aspects), and bilateral lower extremities. Burns to both lower extremities were circumferential, with poor peripheral perfusion noted on the right side. A medial and lateral escharotomy was performed on the right lower extremity. Sharp debridement of devitalized skin was undertaken, and the patient was scrubbed with dilute 4% chlorhexidine solution. Once clean, the wounds were wrapped in Silverlon dressings and secured with gauze. Bronchoscopy was performed, confirming a supraglottic inhalational injury, but no obvious infraglottic injury. A central venous catheter and femoral arterial monitoring catheter were also placed. The patient was transferred to the intensive care unit for ongoing resuscitation.

Because of persistent metabolic acidosis, hypotension, and low urine output, colloids in the form of 5% albumin and fresh frozen plasma were also administered. Augmentation of mean arterial pressure was also undertaken with vasopressors (levophed and dopamine). Despite delayed presentation and subsequent delayed resuscitation, the patient responded well to therapy and was deemed to have been successfully resuscitated 23 hours after presentation. His base deficit normalized, urine output improved, and fluid requirements lessened. Vasopressors were started at hour 10 postburn and discontinued at hour 23 postburn. Enteral feedings via nasoduodenal tube were initiated approximately 12 hours after presentation. Feedings were titrated to goal. He tolerated these well.

Postburn day 3, the patient was taken to the OR for excision and grafting. All full-thickness burns, with the exception of the face, were tangentially excised. Excision was down to reticular dermis in most places, although excision down to subcutaneous fat was also necessary in some regions. No fascial level excision was necessary. Using meshed (1.5:1) and unmeshed (sheet) autograft, we covered the hands, wrists, and posterior thighs. The patient's wounds were then covered entirely in Silverlon and then WVAC. The TBSA of the WVAC was estimated to be 60%. Because of the large area covered, standard WVAC pumps were ineffective at maintaining a constant suction and seal. Therefore, the WVAC was placed to high wall suction with intervening suction canisters to capture wound effluent.

Complications included growth of *Streptococcus* sp. from the sputum, but without clinically significant pneumonia, nor was there radiographic evidence of such. From blood cultures, *Enterobacter* sp. and *Escherichia coli* grew, but again without clinically evident sepsis. The patient was persistently febrile, and all positive cultures were obtained during temperature spikes deemed significant enough to prompt culture acquisition. Infections responded to appropriate antibiotic therapy.

With prior evidence of high mortality in burns this large, additional innovations were pursued to aid in wound closure. An abstract by Bergmann[3] was reviewed. This abstract reported a 100-fold increase in wound coverage with a technique of skin mincing, as originally described by Meek.[4] The mincing device (Wright Medical Technology, Inc., Arlington, TN), developed by Eriksson, was procured and used to cover a total of 6% TBSAB during two of the planned operative periods. The chest (1037 cm^2) and right ankle (130 cm^2) were covered using the mincing technique. Both times, the mincing technique was used when there was limited donor skin and in body regions that could be closely observed, which were geographically more flat and which had wound bed that appeared well vascularized and prepared to accept donor skin.

In brief, the technique uses a manually driven knife with 30 circular blades arranged 0.8 mm apart. The donor skin is placed with the dermis side down on a rubber mat and pressure is applied, cutting the skin lengthwise. The mat is then rotated 90 degrees, and the skin is cut cross-wise, leaving cubes of dermis (Figures 1A to C).

The donor skin is kept moist, and the donor site is prepared with a grid pattern to ease placement. For this, we used latex vessel loops secured with skin staples.

The micrografts were then manually placed on the wound bed with forceps. We were not concerned with dermal orientation, per inventor's recommendation (personal communication, Elof Eriksson, MD, 2009, oral communication). The micrografts were placed approximately 5 mm apart. The grid lines were removed, and the grafts were covered in a layered fashion with one layer consisting of a silver product. The outer dressings were changed every 3 days until approximately 80% was re-epithelialized (Figure 2). The wound was then daily dressed with antibiotic ointment and sterile dressings.

The patient was returned to the OR every 3 days for WVAC change. This interval was chosen because fluids were noted to accumulate beneath the WVAC dressings by the third day, at times causing a "blistering" effect of the adhesive drape. A total of four operations were required to completely cover open wound, including a final operation to regraft several small nonhealing wound beds.

The postoperative course of the patient continued to be remarkably uneventful. He began taking nutrition *per os*, was communicative with family and caregivers, and was begun on a rigorous physical therapy regimen to improve strength.

Frequent re-evaluation of the micrografted tissue showed healing wounds that were reminiscent of

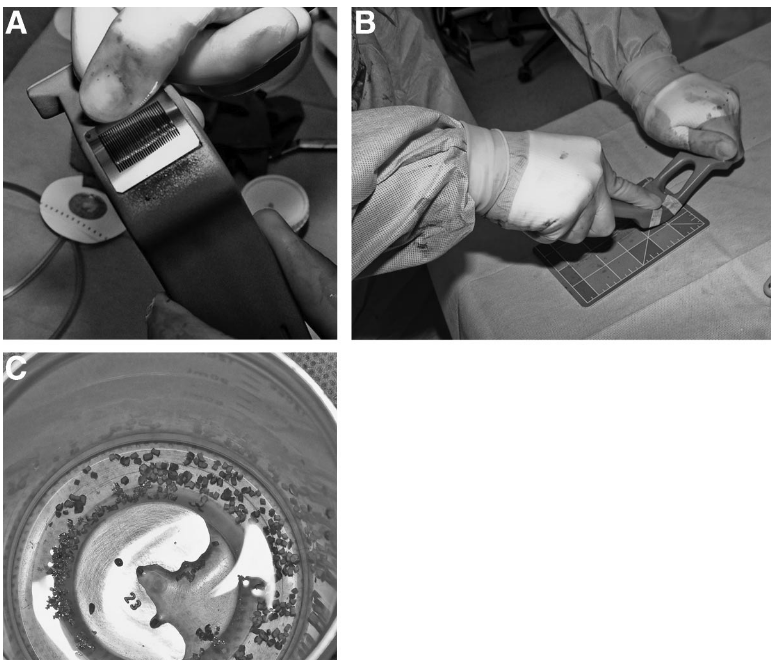

Figure 1. Equipment for mincing skin. A, Mincing device developed by Elof Erikkson, MD. Note the circular blades. B, Using device to mince skin. C, Minced pieces in specimen cup. Pieces are 0.8 mm in diameter (approximately 0.5 mm^3).

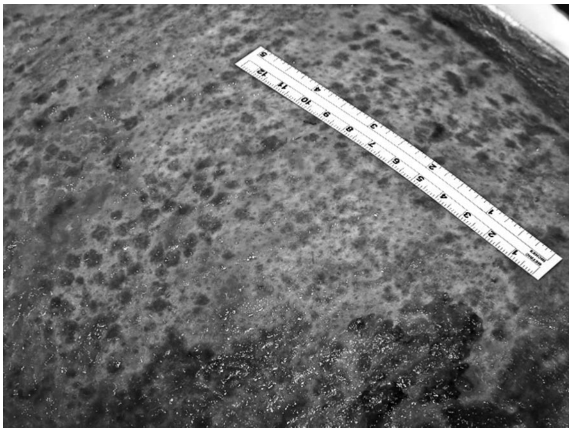

Figure 2. Clinical image. Patient's chest grafted using Meek technique. This is at approximately 14 days after grafting.

healed donor sites. No significant graft loss was noted, and total time to complete closure was approximately 30 days (Figure 3).

The patient was ultimately moved to the general hospital ward on postburn day 43. He was subsequently discharged on hospital day 61.

DISCUSSION

Burn patients in the United States and other developed countries have enjoyed the advancement of surgical and medical care, which, together, leads to increased survival rates in even very large burn injuries. These changes have occurred, in large part, over the past 15 to 20 years. In contrast to this is the level of care available in third-world countries. Although the knowledge and skills are certainly more than adequate, there remains a significant deficit in resources to care for patients with large burn injuries.

Figure 3. Clinical image. Patient's chest grafted using Meek technique showing completely healed burn wound.

Limited local resources, including minimal critical care wherewithal, poor hygienic conditions, and nonexistent availability of wound coverings, such as homograft, contribute to the high mortality seen in underdeveloped countries such as Iraq. The U.S. military presence has not been able to overcome all of the obstacles faced by local healthcare providers. Thus, when patients with very large burns present for care, certain options remain unavailable; high mortality remains a significant issue in host national casualties.

We present the case of a host nation civilian who sustained a large burn injury. The case was managed using both conventional and unconventional means. In the absence of cadaveric graft, a WVAC was used. We believe that this played a significant role in the survival of the patient.

The second innovation was the use of a grafting technique that, although recognized in the literature, has yet to take a strong hold on the burn community. Our patient was able to be completely grafted in four trips to the OR. In two of these trips, we covered a total of approximately 6% TBSA with minced skin graft, once autograft was exhausted. It could be argued that even in aggregate, the area covered is relatively small and insignificant. However, we believe that it is just this burden along with opening more wound from large area donor sites that mostly likely contributes to high mortality in this patient population, and that any wound closure is better than no wound closure.

The mincing technique is simple and readily adaptable in almost any environment. However, placement of the graft is extremely time intensive. It requires much more time to cover the wound than is necessary to cover with standard skin grafting. However, in the absence of adequate donor sites, such as in a large burn, we believe that it is a worthwhile pursuit as a means to an end (Table 1).

A recent report by Lumenta et al[5] highlights the Meek and other techniques as viable options for burn wound coverage when there are limited donor sites

Table 1. Skin grafting techniques used by body region and area covered

Body Region	Type of Skin Graft	Approximate %TBSA (cm^2)
Face (including ears) and hands	Sheet grafts	6 (1560)
Arms, lower anterior torso, and anterior and posterior legs	Meshed grafts (2:1)	41 (9000)
Upper and mid-torso and bilateral (anterior) ankles	Mincing technique	7 (1560)

for harvest. In the report by Lumenta et al, six of their 10 patients were grafted using Meek's micrografting technique. The mean number of operations for the Meek group was 6.5, and the length of stay was 85.7 ± 14.8 days. The mean TBSAB was 75.2 ± 13.2. Although their technique varied and equipment used for the mincing of the skin was different, outcomes were clearly excellent, as was seen in our patient.

Data collection regarding mortality of host nationals cared for at U.S. military medical facilities in the theaters of operation is incomplete. However, anecdotally, we believe that this patient to be a one of only a handful of patients to have survived such a large burn injury (>50% TBSA). Data from Iraqi medical facilities are not available for comparison.

Although U.S. burn centers continue to boast low mortality rates, those patients with very large burns are the ones most at risk for dying. U.S. burn centers are fortunate to have advanced wound care options such as CEA and cadaveric skin grafts as both permanent and temporary wound coverage, respectively, when donor skin is limited. This report highlights the use of two additional wound care options, even for very large burns, that may aid in additional improved outcomes in the critically burned patient.

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