Microvascular reconstructive surgery in Operations Iraqi and Enduring Freedom: The US military experience performing free flaps in a combat zone

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BACKGROUND: Local nationals with complex wounds resulting from traumatic combat injuries during Operations Iraqi Freedom and Enduring Freedom usually must undergo reconstructive surgery in the combat zone. While the use of microvascular free-tissue transfer (free flaps) for traumatic reconstruction is well documented in the literature, various complicating factors exist when these intricate surgical procedures are performed in a theater of war.

METHODS: The microvascular experiences of six military surgeons deployed during a 30-month period between 2006 and 2011 in Iraq and Afghanistan were retrospectively reviewed.

RESULTS: Twenty-nine patients presented with complex traumatic wounds. Thirty-one free flaps were performed for the 29 patients. Location of tissue defects included the lower extremity (15), face/neck (8), upper extremity (6). Limb salvage was successful in all but one patient. Six of eight patients with head and neck wounds were tolerating oral intake at the time of discharge. There were three flap losses in 3 patients; two patients who experienced flap loss underwent a successful second free or regional flap. Minor complications occurred in six patients.

CONCLUSION: Microvascular free tissue transfer for complex tissue defects in a combat zone is a critically important task and can improve quality of life for host-nation patients. Major US combat hospitals deployed to a war zone should include personnel who are trained and capable of performing these complex reconstructive procedures and who understand the many nuances of optimizing outcomes in this challenging environment. (*J Trauma Acute Care Surg*. 2013;75: S228–S232. Copyright © 2013 by Lippincott Williams & Wilkins)

LEVEL OF EVIDENCE: Therapeutic study, level V.

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Impressive advances in resuscitation, casualty evacuation, and damage-control surgery in the care of combat wounded have been made during the past 10 years during the Operations Iraqi Freedom (OIF) and Enduring Freedom (OEF). These improvements helped to reduce mortality rates from 25% in previous conflicts to less than 10% for combat-injured US and North Atlantic Treaty Organization (NATO) service members in Iraq and Afghanistan.[1]

With improved survival comes the challenge of managing massive and complex wounds that would likely have been unsurvivable in earlier conflicts. The vast majority of US and NATO service members who experience these injuries undergo delayed reconstructive surgery after evacuation from the combat zone. Microvascular free-tissue transfer (free flap) is often the optimal method of reconstruction, using donor tissue from an anatomic site distant from the zone of injury; however, special surgical skills and instruments are required. Multiple reports of successful free-flap reconstruction in combat-injured service members performed after evacuation from the combat theater have been published.[2–9]

In both OIF and OEF, local-national military, police, and civilians experience combat-related injuries at a much higher rate than either US or NATO service members.[10] When local nationals experience complex wounds requiring microvascular reconstruction, definitive surgery must often be performed in the combat theater. In general, Iraqi and Afghan host-nation medical services are not available or capable of performing this complex form of reconstruction, so US and NATO surgeons are frequently the only alternative for care.

While the use of free flaps for traumatic reconstruction is well documented in the literature, various complicating factors exist when these intricate surgical procedures are performed in a theater of war.[11–13] Although numerous free flaps have been performed in the combat zone on local nationals, an organized review and discussion of this topic has not yet been undertaken by the US military.

PATIENTS AND METHODS

The operative logs of five head and neck surgeons and one plastic surgeon deployed to Iraq and Afghanistan during a

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30-month period between 2006 and 2011 were used to generate a list of study subjects who underwent microvascular reconstruction of a combat-related traumatic soft tissue defect. Surgeons were deployed to various combat support hospitals (CSHs) in the two countries. All Iraqi or Afghan military, police, combatants, or civilians who underwent free-flap reconstruction were included.

Data collected on all study patients included nationality, mechanism of injury, microvascular surgical procedures, and perioperative complications. For patients who underwent reconstruction of an extremity wound, limb salvage was assessed. In those who underwent head and neck free-flap reconstruction, status of oral diet at the time of discharge was obtained.

RESULTS

Twenty-nine patients presented with complex traumatic wounds. All patients were treated with microvascular free tissue transfer for optimal management of their soft tissue defects. Five head and neck surgeons and one plastic surgeon managed these patients with the number of free flaps performed per surgeon ranging from 13 to 2. A total of 31 free flaps were performed for the 29 patients. Location of traumatic tissue defects included the lower extremity (15), face/neck (8), and upper extremity (6). Donor sites for free flaps included the anterolateral thigh (10), radial forearm (9), fibular osteocutaneous (4), vertical rectus abdominis (4), latissimus dorsi (2), gracilis (1), and parascapular (1). Mechanism of injury was improvised explosive device (IED) in 14, gunshot wound in 9, and blunt force trauma in 6 patients. Limb salvage was successful in all but one patient treated for an extremity injury. Six of eight patients with head and neck wounds were tolerating oral intake at the time of discharge. There were three total flap losses in three patients (9.7%); in two patients who experienced flap loss, a second free flap or a regional flap was performed successfully. One total flap loss for a lower-extremity injury resulted in amputation. Minor complications occurred in six patients, including venous congestion requiring thrombectomy (3), partial flap loss, donor site hematoma, and small wound dehiscence. Complications rates, including flap loss, were similar for each mechanism of injury.

DISCUSSION

Definitive management of soft tissue defects typically follows an algorithm from simple (healing by secondary intention, primary closure, etc.) to more complex (regional flap, free flap, etc.) based on multiple factors including extent of injury, concomitant injury, timing, equipment available, and surgeon skill set.[6,7,14,15] Simpler methods of reconstruction are often more desirable, especially in a low-resource setting. In general, large soft tissue defects of certain areas of the body, including the distal lower extremities and the head and face region, are often best reconstructed with either regional or free flaps. The alternative to reconstruction of a large soft tissue injury of an extremity is often amputation (Fig. 1*A* and *B* and Fig. 2*A* and *B*).[13,16] For large head and face wounds, failure to successfully reconstruct may lead to pharyngocutaneous fistula, inability to speak or swallow, and significant disfigurement (Fig. 3*A* and *B*).

Traumatic combat wounds frequently demonstrate extensive tissue damage and are often slow to heal without soft tissue coverage.[6,7] Concomitant injuries from high-velocity gunshot wounds or explosive ordinance are extremely common and often limit options for reconstruction. The massive amount of energy transfer and bacterial contamination associated with these types of wounds have been shown to increase free flap failure rates.[17,18] Despite these factors, US and NATO service members injured in OIF and OEF have undergone free-flap reconstructive surgery for combat trauma after evacuation to their native countries' medical centers with excellent success rates.[2–4,19]

Microvascular reconstructive surgery for combat wounds is not new to OIF and OEF. In the 1990s, war injuries in Croatia were treated using free-flap reconstruction with good results. Tajsic and Husum[20] described his experience in the Balkans crisis, completing 34 free flaps for extremity combat injuries. Despite performing microsurgery in a "low-resource" setting, he had a complication rate of only 8.3%, demonstrating that complex reconstruction could be successfully achieved in the subacute period on combat wounds. The 9.7% flap failure rate in this series compares favorably to the Balkan experience. Of the three total flap losses, one injury was from a gunshot wound, one from an IED, and one from blunt force trauma. Minor complications

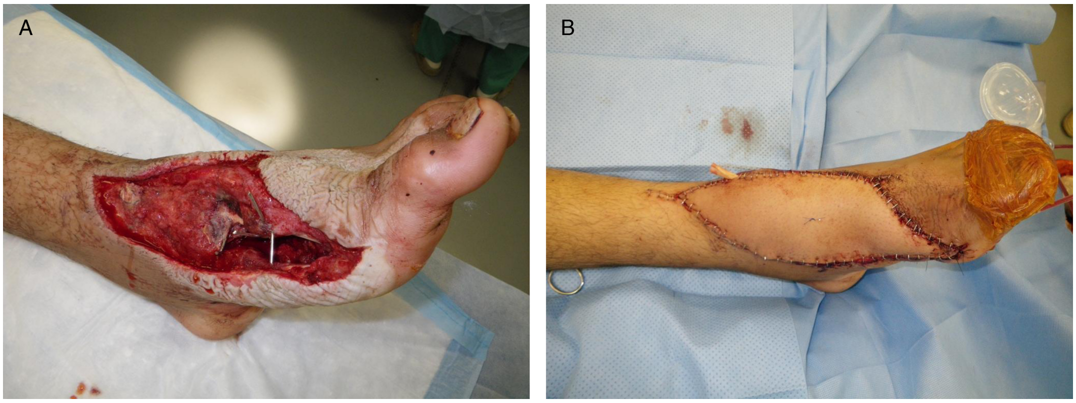

Figure 1. (*A*), Left forefoot defect after three accidental self-inflicted gunshot wounds with an AK-47 assault rifle. The patient had a sensate foot but significant bone and soft tissue loss. (*B*), Immediately following soft tissue reconstruction using an anterolateral thigh free flap.

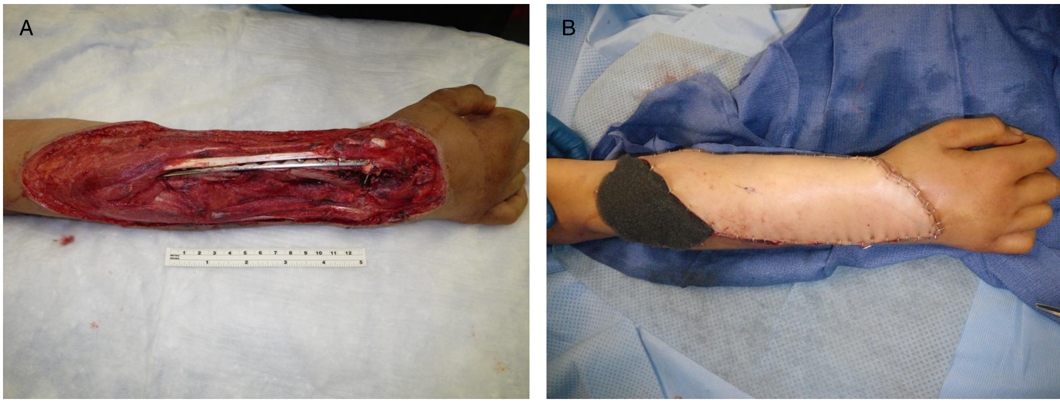

Figure 2. (*A*), Massive right forearm defect from an IED blast in an Afghan child after multiple washouts and open-reduction internal-fixation of a comminuted radial fracture. (*B*), After inset of an anterolateral thigh free flap, the most proximal portion of the injury is uncovered, and a negative pressure wound therapy is placed in preparation for a skin graft at a later time.

occurred equally among all three mechanisms of injury. The experience if Tajsic and Husum in the Balkans, was at a regional hospital specifically set up to care for the local population and was relatively removed from the area of combat operations. When dealing with local-national patients in a combat zone at a military CSH, however, multiple extenuating factors exist, which must be taken into consideration when deciding how to best treat a massive traumatic soft tissue defect.

Equipment and Skills

Specialists who are typically trained to perform microvascular reconstructive surgery include plastic surgeons, hand surgeons, and head and neck surgeons. Although personnel from all of these specialties have deployed to both Iraq and Afghanistan, there is currently no uniform requirement that hospitals have these skills available. The limited resources available demanded a multidisciplinary approach be used for all of these reconstructive cases. For example, head and neck surgeons who perform microvascular reconstructive surgery are not typically trained in extremity reconstruction. However, since extremity injuries are the most common combat wounds, when a complex microvascular reconstruction was recommended for limb salvage, the treating orthopedic surgeon worked closely with the head and neck surgeon to perform the appropriate microvascular reconstructive surgery.

Preexisting medical capabilities differed significantly between Iraq and Afghanistan. Iraq had fairly sophisticated medical infrastructure and care available, so patients could often be transferred to local-national medical facilities for follow-up care. In Afghanistan, however, specialized medical care was virtually nonexistent outside of NATO facilities, so nearly all definitive care needed to occur before discharge from the CSH.

Location

Medical assets in OIF and OEF are arranged so that injured patients can be treated and evacuated to higher levels of care based on acuity of injury. Lifesaving measures are performed at or near the point of injury, and patients are transported to higher echelons of care after stabilization. The CSH constitutes the most advanced military medical care available in the combat theater, and all of the free flaps performed in this study were performed in US CSHs. In Afghanistan and many parts of Iraq, the CSH offers the most sophisticated specialty and surgical care available to local nationals.

Figure 3. (*A*), Large soft tissue and bony defect of the left face sustained from a shotgun blast. (*B*), Postoperative photo after soft tissue reconstruction using an anterolateral thigh free flap.

The diversity of various CSHs is extremely wide, ranging from state-of-the-art fixed facilities in the middle of large cities to tent hospitals situated in the middle of the desert. Available surgical specialties and equipment vary as well, and it is not uncommon that a CSH does not have either a surgeon with microvascular skills assigned to it or dedicated microvascular instruments available. Some of the surgeons in this series used operating microscopes, while others performed microvascular anastamoses under loupe magnification. Several surgeons had access to good quality microvascular instruments and suture, while one surgeon performed several free flaps using a major vascular surgery set and 7-0 Prolene suture.

Although a range of microvascular surgical techniques and required instrumentation are described, there are no uniformly accepted standards. Perhaps most important to successful outcomes in microvascular reconstructive surgery are knowledge of microvascular anatomy, meticulous tissue handling, and good surgical judgment.

Timing

There is much controversy surrounding the timing of microvascular reconstructive surgery for traumatic defects. In the civilian trauma literature, Godina[21] demonstrated increased flap failure and complications when microvascular free tissue transfer was performed more than 72 hours after injury. Similar findings of decreased complications with early free-flap coverage are reported in multiple other studies. When surgery is not possible within the first 3 days, many recommend a delayed reconstruction until all wounds are clean and infection is controlled.[11,12,22–24]

Wounds from combat trauma in OIF and OEF, however, are significantly different from those seen in civilian trauma centers. The vast majority of injuries in this study are from high-velocity gunshots and IEDs, both of which tend to cause heavily contaminated wounds on the battlefield. In addition, most of these patients had multiple injuries requiring aggressive resuscitation and stabilization as well as multiple surgical procedures and/or washouts of wounds before definitive reconstructive surgery. For these reasons, from either a systemic or a wound-specific standpoint, no trauma patient in this series was ready to undergo microvascular reconstruction within 72 hours. All of the free flaps in this series were performed within 1 month of injury, the so-called subacute period when Godina reported the highest microvascular failure rate after trauma. The actual time from injury to reconstruction was not available for each individual patient. Further delaying reconstructive surgery might be optimal for patient outcome but places significant stresses on critical medical resources in the combat theater. Typical flap failure rates in the literature are 1% to 3%. Time constraints may have been a contributing factor in the total flap failure rate in this series of 9.7%.

Bed Space

In a combat zone, one invariable responsibility of military surgeons is to take into account the success of the military mission. With the constant potential for mass casualties, maintaining available bed space is a high priority at all medical facilities.

For US and NATO injured service members, prompt evacuation out of the combat theater after stabilization is standard practice, ensuring medical assets are available for future casualties. For wounded local nationals in OIF and OEF, however, options for definitive medical and surgical care outside of a CSH are limited or nonexistent. These patients often remain in the CSH until either treatment is complete or similar care is available at a local facility. Reconstructive surgery on local-national patients is often performed at the earliest opportunity, once the patient is stable and involved wounds are clean regardless of time since injury.

Follow-up and Rehabilitation

The vast majority of local-national patients treated at US and NATO facilities in OIF and OEF do not have access to further care once discharged. For this reason, the status of patients at discharge is the last available data point, and long-term follow-up is usually not available. Responsibility for follow-up care rests with local providers, who are frequently either nonexistent or overwhelmed with other patients.

In this series, there is no long-term follow-up, and the ultimate status of limb salvage or ability to take oral intake is unknown. Much like advanced medical care in developed nations, the reconstructive surgeons in this series worked as part of a multidisciplinary team always trying to optimize outcomes based on specific injury and overall situation of each individual patient.

Rehabilitative services after microvascular reconstructive surgery, especially when performed for limb salvage or head and neck reconstruction, may offer improved functional outcomes for these challenging patients.[25] These services are not readily available in either Iraq or Afghanistan. With both poor long-term follow-up and lack of postoperative rehabilitative services, it is unclear whether the patients in this series ultimately benefitted from microvascular reconstructive surgery despite the excellent short-term results obtained with regard to limb salvage and swallowing at the time of discharge.

Limb Salvage Versus Amputation

The question of limb salvage versus amputation for massive extremity trauma presents an exceptionally difficult dilemma. Scoring systems such as the Mangled Extremity Severity Score (MESS) have been verified in civilian trauma as effective tools to help direct this decision. However, Brown et al.[13] found that the MESS did not help decide whether amputation was appropriate in combat wounds and recommended that military patients with ballistic extremity injuries should be evaluated differently from civilians.[16,26,27]

In the US and other developed countries, outstanding prostheticrehabilitation offers excellent functional outcomes for many combat-injured amputees, and this fact may play a role in a patient's decision for amputation over attempted limb salvage. In Iraq and Afghanistan, however, both prosthetic and physical rehabilitative services are extremely limited.[25] Cultural and religious beliefs that strongly discourage the loss of any body part or organ also exist, so there may be a strong patient desire for limb salvage. After extensive preoperative counseling, all patients in this series desired attempted limb salvage with a microvascular free flap. At the time of discharge, the overall limb salvage rates were comparable with those reported in the literature for other combat wounded patients. Unfortunately, with the short follow-up period, the ultimate status of these patients is unknown.

Military Mission

The role of the US military in combat operations continues to evolve and often includes nation building and support of host-nation forces. As the overall military mission changes, medical assets, including providers, equipment, and levels of available care, need to remain flexible. Inevitably, combat casualties will include local-national personnel, and adequate care may not be available outside of US medical facilities. From both a diplomatic and humanitarian standpoint, it may be beneficial to provide some level of care to local nationals injured in a combat zone.

CONCLUSION

Microvascular free tissue transfer reconstruction of complex tissue defects in a combat zone is a critically important task and can be performed successfully in a variety of settings, including relatively austere conditions. Short-term limb salvage rates and functional outcomes after microvascular reconstruction are excellent and may improve quality of life for host-nation patients. Major US combat hospitals deployed to a war zone should consider including personnel who are trained and capable of performing these complex reconstructive procedures and who understand the many nuances of optimizing outcomes in this challenging environment.

AUTHORSHIP

All authors conceived and designed the study, acquired the data, and revised the manuscript. C.K., B.M., and J.C.S. analyzed and interpreted the data. C.K. and J.C.S. drafted the manuscript.

DISCLOSURE

The authors declare no conflicts of interest.

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