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The complete management of extremity vascular injury in a local population: A wartime report from the 332nd Expeditionary Medical Group/Air Force Theater Hospital, Balad Air Base, Iraq

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Background: **Although the management of vascular injury in coalition forces during Operation Iraqi Freedom has been described, there are no reports on the in-theater treatment of wartime vascular injury in the local population. This study reports the complete management of extremity vascular injury in a local wartime population and illustrates the unique aspects of this cohort and management strategy.**

Methods: **From September 1, 2004, to August 31, 2006, all vascular injuries treated at the Air Force Theater Hospital (AFTH) in Balad, Iraq, were registered. Those in noncoalition troops were identified and retrospectively reviewed.**

Results: **During the study period, 192 major vascular injuries were treated in the local population in the following distribution: extremity 70% (n = 134), neck and great vessel 17% (n = 33), and thoracoabdominal 13% (n = 25). For the extremity cohort, the age range was 4 to 68 years and included 12 pediatric injuries. Autologous vein was the conduit of choice for these vascular reconstructions. A strict wound management strategy providing repeat operative washout and application of the closed negative pressure adjunct was used. Delayed primary closure or secondary coverage with a split-thickness skin graft was required in 57% of extremity wounds. All patients in this cohort remained at the theater hospital through definitive wound healing, with an average length of stay of 15 days (median 11 days). Patients required an average of 3.3 operations (median 3) from the initial injury to definitive wound closure. Major complications in extremity vascular patients, including mortality, were present in 15.7% (n = 21). Surgical wound infection occurred in 3.7% (n = 5), and acute anastomotic disruption in 3% (n = 4). Graft thrombosis occurred in 4.5% (n = 6), and early amputation and mortality rates during the study period were 3.0% (n = 4) and 1.5% (n = 2), respectively.**

Conclusions: **To our knowledge, this study represents the first large report of wartime extremity vascular injury management in a local population. These injuries present unique challenges related to complex wounds that require their complete management to occur in-theater. Vascular reconstruction using vein, combined with a strict wound management strategy, results in successful limb salvage with remarkably low infection, amputation and mortality rates. (J Vasc Surg 2007;45:1197-1205.)**

Reports that document wartime vascular injury have resulted in significant contributions to the understanding of vascular trauma. Experiences with the management of vascular injury in the wounded soldier exist from nearly all military conflicts since the First World War.[1-6] Despite this vast experience treating injured troops, who are traditionally evacuated out of the theater for completion of their care, there have been few reports on vascular injury in a local wartime population. Several reasons exist for the paucity of such reports, the most likely being the lack of access for local populations to United States (US) theater hospitals (personal communications with NM Rich, MD Col (ret) USA MC regarding experience with Vietnam Vascular Registry). Although small numbers of locals may have been cared for at such facilities in past wars, they were the distinct exception, and no large series documenting their care exists.

In contrast with previous more conventional wars, the current conflict sees the US military supporting the development of a new national army and police force. Simultaneously, the conflict targets these national and civilian institutions, as well as the populace itself, by using unconventional tactics all within an urban setting. In this situation, access to US surgical hospitals has been made available

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Fig 1. Aerial view of the 332nd Air Force Theater Hospital, Balad Air Base, Iraq, established in September 2004. This is the first Air Force Theater Hospital since the Vietnam War. The front left inset shows the facility as it looks after tent replacement in November 2005.

to a large number of the local population. Given that much of the definitive care of these individuals must be rendered at these theater hospitals, an opportunity exists to examine the effectiveness of specific surgical management strategies. Vascular injuries in this setting occur in a wide age range of patients (pediatric to geriatric) and include complex soft tissue wounds that must be managed to complete closure before patient discharge.

The objective of this study is to provide an account of wartime extremity vascular injury in a local population. An additional objective is to scrutinize management strategies related to vascular reconstruction and complex soft tissue wounds, and report early infection, limb salvage, and mortality rates.

METHODS

Demographics. From September 1, 2004, through August 31, 2006, all vascular injuries treated at the central level III facility in Iraq (Fig 1, Fig 2) were prospectively registered into a clinical database. Institutional Review Board approval was obtained for the review of this vascular registry. The subset of noncoalition patients was then identified, and these data were retrospectively reviewed. This group consisted of civilians, National Guard, Army, police officers, and suspected insurgents. The clinical management did not differ based upon patient status. To maintain uniformity, this study cohort will be referred to as the *local population* throughout the remainder of the report. Extremity vascular injuries in this group include those in which limb salvage was attempted. Vascular injuries associated with mangled extremities that were amputated in the trauma bay or early in the operating room were not included.

Basic demographic data collected included patient age, length of hospital stay, number of operations, and date of injury. All of the patients in this cohort underwent vascular operations and subsequent inpatient wound management at the 332nd Expeditionary Medical Group (EMDG)/Air Force Theater Hospital (AFTH). The AFTH is structured to accommodate and maintain this patient care capability and at no time did this clinical practice compromise access to care for coalition troops.

Injury patterns. Patterns of injury were documented, noting the mechanism of vascular injury, site and type of vessel injured, and the presence of associated nonvascular trauma. Surgical interventions were analyzed by the type of repair performed and the conduit used (autogenous vein or synthetic graft). The method of wound closure was documented, including primary wound closure, delayed primary closure after negative pressure wound therapy (Kinetic Concepts, Inc., San Antonio, Tex), or split-thickness skin grafting after muscle flap coverage. Early outcomes were determined, including need for amputation, wound infection requiring operation and drainage, graft infection with acute anastomotic disruption, and death.

Diagnosis and repair of vascular injury. Most vascular injuries were diagnosed in the presence of hard signs, primarily hematoma, hemorrhage, or acute ischemia. In this setting, most patients went immediately to the operating room for exploration and revascularization. Doppler examination and use of the injured extremity index served as important adjuncts. Diagnostic arteriography was avail-

Fig 2. One of the three Air Force Theater Hospital operating rooms at the Balad Air Base, Iraq. Each converted cargo container can support two operations at any given time, as shown here.

able only in the final year of this study period and played a limited role in the diagnosis of vascular injury.

Vascular repair was completed within 4 to 6 hours from the time of injury in nearly all cases. There were patients who were revascularized more quickly and the rare case where revascularization did not take place for up to 12 hours. In the latter situation, triage or damage control scenarios dictated placement of a temporary vascular shunt while life-threatening injuries were addressed and orthopedic stabilization occurred. In no case was the temporary shunt in place for more than 12 hours.

Limitations. Limitations in the data set are related to mass casualty events, language barriers, rotation of surgeons, and surgeon fatigue. This has prevented the exact recording of wounding and surgical detail in some patients in this cohort. Specific numbers and percentages are reported on the variables for which complete data are available. Although the overall distribution of vascular injury is reported (extremity, neck and great vessel, and torso), the focus of this experience is the management of extremity vascular injuries with associated complex soft tissue wounds.

RESULTS

Incidence and distribution of vascular injury. During the 2-year study period, 4323 local noncoalition patients were admitted for treatment of traumatic injuries at the AFTH (Fig 1, Fig 2), which represented 40% of the 10,953 total hospital admissions. Of these, 192 (4.4%) had a major vascular injury in the following distribution: extremity, 134 (70%); neck and great vessel, 33 (17%); and torso, 25 (13%). The age range of patients with vascular injury was 4 to 68 years, with 12 patients younger than 18 years old.

A penetrating mechanism was responsible for 88% of wounds. Nonpenetrating blunt vascular injuries were only seen in 3% of cases (n = 6). The mechanism of penetrating vascular injury was most commonly an explosive device. High-velocity gunshot wounds were also common, although the exact cause of penetrating and blunt injuries was often not known with certainty. There were no stab wounds in this cohort.

Upper extremity injuries. Forty upper extremity arterial injuries were treated in the following anatomic distribution: four axillary, 25 brachial, and 11 radial or ulnar. Interposition great saphenous vein was the reconstruction option of choice in upper extremity injuries, although ligation was performed when concomitant injuries prevented reconstructive efforts and a distal arterial signal was present indicating collateral circulation. Three of the four axillary artery injuries were managed with interposition bypass. Reversed great saphenous vein was used in one patient and prosthetic in two patients. The fourth patient with axillary artery injury was in extremis and underwent ligation.

Brachial artery injury was identified in 25 patients: 21 underwent an interposition repair using autologous vein, two had primary repair, and two primary ligations were performed. Forearm arterial injuries were managed in 11 patients. Interposition bypass using autologous vein was performed in three instances, and ligation was undertaken in six. Primary repair of the artery was performed in two instances.

In the upper extremity, 15 combined arterial and venous injuries were identified for an incidence of 38%. Three axillary vein injuries were repaired, and the 12 remaining upper extremity venous injuries were ligated.[7]

Table. Anatomic distribution of extremity vascular injuries

Anatomic location	*Artery*	*Injuries (n = 134)*	*%*
Upper extremity		(40)	(29.9)
	Axillary	4	3.0
	Brachial	25	18.7
	Radial/Ulnar	11	8.2
Lower extremity		(94)	(70.1)
	Iliofemoral	9	6.7
	SFA	29	21.6
	PFA	6	4.5
	Popliteal	29	21.6
	Tibial	21	15.7

SFA, Superficial femoral artery; *PFA,* Profunda femoral artery.

Lower extremity injuries. During the study period, 94 lower extremity arterial injuries were treated in the following distribution: 9 external iliac and common femoral, 29 superficial femoral, 6 profunda femoral, 29 popliteal, and 21 tibial. Interposition graft using autologous vein was the reconstruction of choice in the lower extremity. Vein patch angioplasty or primary repair of the vessel was performed in some patients. Arterial ligation was undertaken in cases of tibial vascular injury or in extreme damage control circumstances (Table).

The nine cases of external iliac and common femoral artery injuries were managed with interposition bypass (n = 1), primary repair (n = 3), vein patch angioplasty (n = 3), and ligation (n = 2). The 29 superficial femoral artery injuries were managed with interposition bypass using vein (n = 22), primary repair (n = 5), and vein patch angioplasty (n = 2). Six profunda femoral artery injuries were managed by either ligation (n = 5) or vein patch repair (n = 1). The popliteal artery was injured in 29 patients, and bypass with vein was performed in 22. Vein patch repair (n = 2) and ligation (n = 5) were also used. The tibial level arteries were injured in 21 patients. Ligation was the most common management at this level (n = 11). Bypass using vein was also performed (n = 6). The rest of the vascular injuries at this level were managed with vein patch (n = 2) and amputation (n = 2).

Concomitant arterial and venous injuries were present in 51 lower extremity cases (61%). The management of these combined injuries varied by the region of the leg that was injured and the patient's hemodynamic status. Either interposition vein graft or lateral venorrhaphy was used to repair 39% of these combined venous injuries. Proximal venous (iliofemoral or axillosubclavian) repairs were pursued whenever the patient's hemodynamic and physiologic state permitted. Popliteal vein repairs were the exception given the extent of penetrating injury and technical challenge of working in this anatomic location. Tibial level vein injuries were routinely ligated. The exact technique of venous repair and anatomic location of venous injury were not documented for all cases.

Great saphenous vein was the conduit of choice in both the upper and lower extremities. The contralateral vein was taken preferentially for lower extremity injuries, although ipsilateral vein was often required. A short segment of one of these was available in most patients for interposition grafting. If not, there were anecdotal cases of adequate saphenous and arm vein being used. In no case was deep vein used for reconstruction, and prosthetic devices were reserved for axillary and other central vascular injuries.

In cases of large-vessel injury and damage control, temporary vascular shunts were often used to maintain distal extremity perfusion until the patient was better able to tolerate definitive vascular repair.[8] As with past experience, continuous wave Doppler played a significant role in these situations.[9]

The management of extremity soft-issue injury. The high-energy mechanisms that caused extremity vascular injury created wounds that were notable for extensive soft-issue destruction (Fig 3, Fig 4). All penetrating soft tissue wounds were explored, débrided, and washed out in the operating room. Most of these wounds underwent placement of a V.A.C. dressing adjunct after exploration and planned re-exploration in 48 to 72 hours. A few wounds were closed primarily at the first operation.[10]

When possible, vascular reconstructions were routed deep through anatomic planes. When not possible, grafts were routed through extra-anatomic or uncommon planes. In either case, coverage with available viable muscle and soft tissue was attempted. Formal muscle flaps were required in <10% of patients and when performed consisted of rotational flaps of the sartorius, gastrocnemius, and rectus abdominal muscles. No free muscle flaps were used in this cohort.

A closed negative pressure dressing (V.A.C.) was applied in the operating room after vascular repair and soft tissue coverage in most cases (Fig 3, Fig 4). This dressing adjunct negated the need for dressing changes on the ward and allowed the use of a closed, more sterile, and tolerable wound management strategy. It is also our experience that this technique accelerated wound contraction and granulation, both of which facilitated delayed primary closure or secondary coverage with split-thickness skin grafting. This experience confirms previously published reports with this dressing adjunct and extends its effective use to more austere conditions.[10,11]

The average length of stay from presentation to definitive wound closure was 15 days (median 11 days). Patients underwent an average of 3.3 operations (median 3, range, 1 to 13). Delayed primary closure or coverage with a split-thickness skin graft was required in 57% of soft tissue wounds. Fasciotomy wounds were managed in a similar manner, with a near equal distribution of closures accomplished by delayed techniques and skin grafting.

Complications. Mortality in the 134 patients with extremity injuries was 1.5% (n = 2). One death was due to overwhelming sepsis and the other to multisystem organ failure. Both occurred after vascular reconstruction and attempts at limb salvage after penetrating injuries, and in both instances, the degree of injury to the bones and soft tissue was such that attempts at salvage may have contrib-

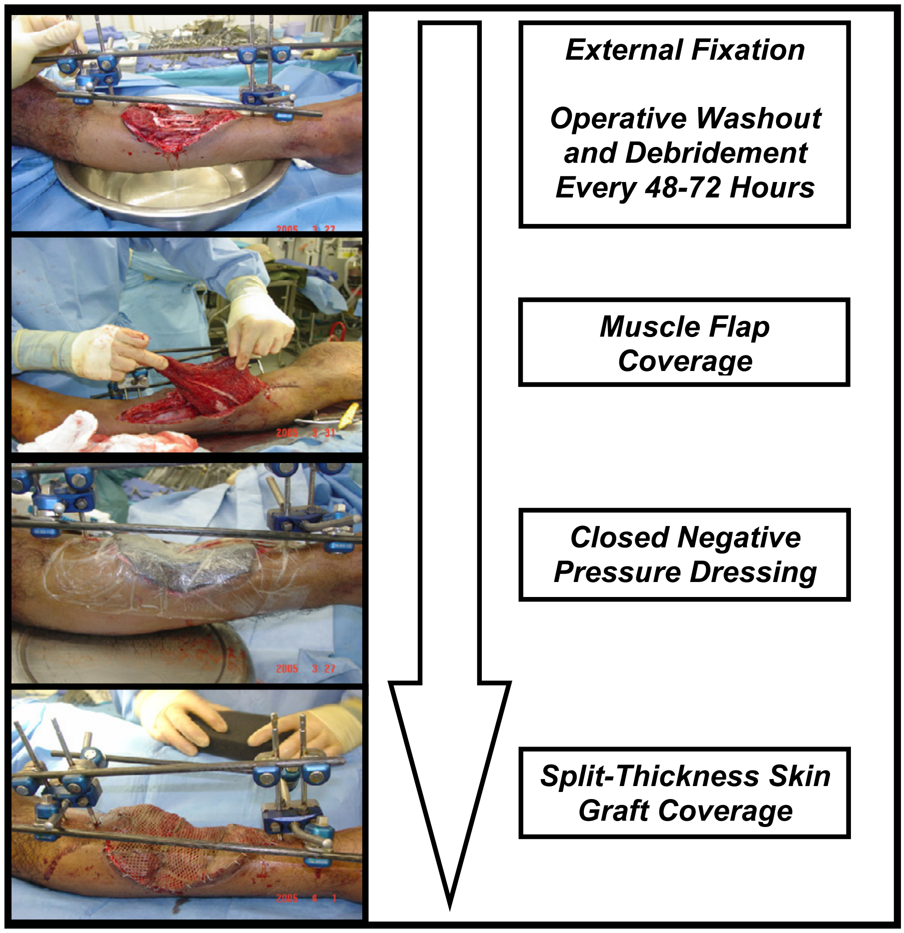

Fig 3. Example of a high-energy lower extremity wound that required popliteal-to-posterior tibial bypass using autologous vein. The strict wound management technique of serial débridement in the operating room, soleus muscle flap coverage, and use of negative pressure wound dressings, followed by split-thickness skin graft, was used to successfully manage this wound.

uted to the deaths. There were a total of 19 other extremity complications (14.2%), which included acute anastomotic disruptions (n = 4), wound infections (n = 5), and delayed amputations (n = 4). Six saphenous vein bypass procedures had early thrombosis and required revision. The four delayed amputations (3%) that occurred in this series resulted from anastomotic disruption (n = 1), uncontrolled sepsis in mangled extremity with patent graft (n = 2), and thrombosed reconstruction with prolonged ischemia (n = 1).

DISCUSSION

The local population comprised 40% of overall casualties admitted to the AFTH during the 24 consecutive months of this study. These patients sustained >190 major vascular injuries, and most were due to explosive devices. Extremity injuries were most common, with the lower extremity being injured twice as frequently as the upper. Definitive vascular repair of extremity wounds was performed at the initial operation with vein as the conduit of choice, including repair in 12 pediatric patients. Complex wounds resulted from these high-energy insults, and all wound care was pursued in the operating room using the V.A.C. adjunct in wounds débrided but not yet closed. Delayed primary closure or secondary coverage with a skin graft was necessary in two thirds of wounds. Overall, the mortality and complication rates were low, with >95% early limb salvage.

Comparison with other experiences. Certain similarities exist when vascular injuries from the Vietnam War are compared with this contemporary experience. In both instances, wounds from explosive devices were most common, followed by high-velocity gunshot wounds. In contrast with previous reports on injured US soldiers, however, extremity vascular injuries in this local population were less frequent and occurred in 70% of patients (Vietnam, 91%, Rich, et al; Operation Iraqi Freedom/Operation Enduring Freedom, 90%, Fox et al).[5,6,12,13] One possible explanation for the lower rate of extremity vascular injury in the local population relates to the absence of protective body armor. Without armor, some patients with extremity vascular

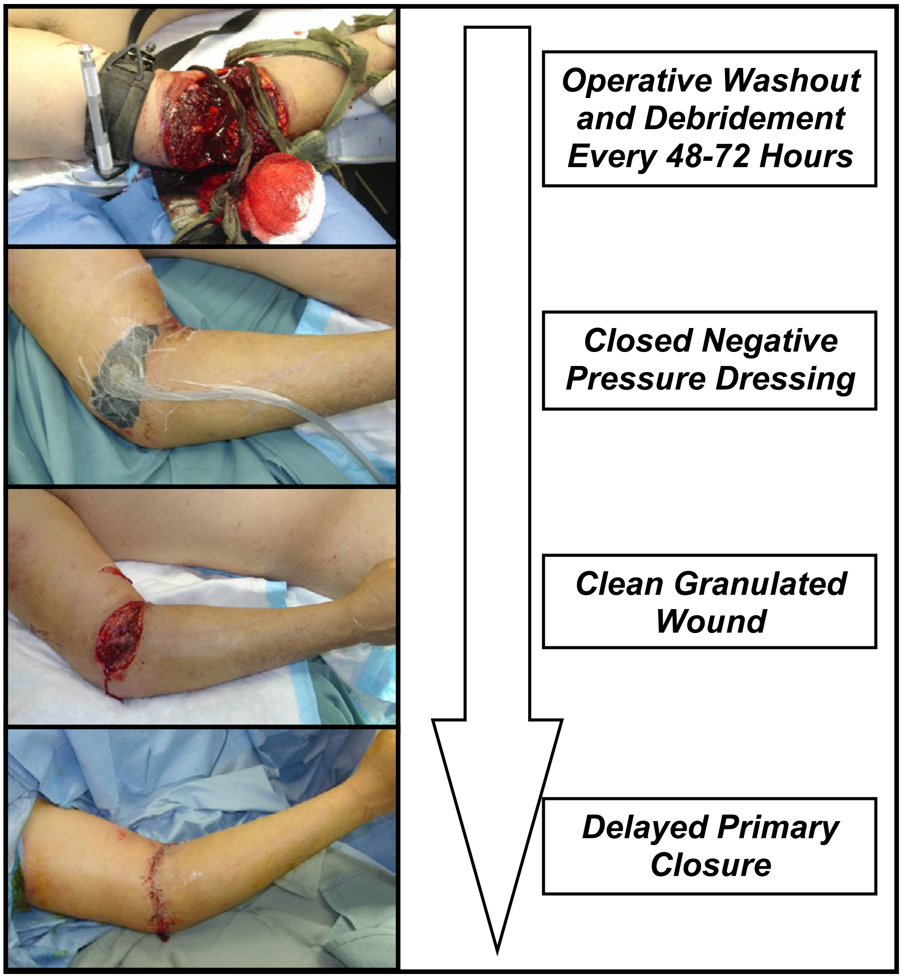

Fig 4. High-energy upper extremity near amputation that required brachial artery reconstruction using autologous vein and repair of radial and median nerves. The strict wound management technique of serial débridement in the operating room and use of negative pressure wound dressings allowed for successful delayed primary closure of this wound.

wounds may die from torso injuries without ultimately having the extremity injuries recorded. Alternatively, some less extensive extremity wounds may initially be considered less severe in this population and the patients are triaged to community care or are simply not registered at a medical facility.

We believe this report is unique in the literature because of the relative paucity of information on vascular injuries in local populations from prior conflicts. Reports from Vietnam and scattered reports from conflicts in Croatia, Lebanon, Georgia, and Afghanistan suggest that locals typically had limited access to the military hospitals (personal communication, NM Rich, MD Col (ret) USA MC).[5-6,14-19] During the current conflict, conditions on the ground have resulted in trauma care being made available to much of the local population.

Adjuncts in the management of extremity vascular injury. Our experience with temporary vascular shunts has recently been reported.[8] Shunts were used in this population mainly in triage or damage control situations preceding orthopedic fixation or when an extensive operation was necessary before vascular repair. Temporary vascular shunt placement was instituted when, in the surgeon's judgment, ischemic time to the extremity could be reduced by its use. Shunts constituted one aspect of the overall aggressive approach to the management of extremity vascular injuries. Our view is that such an aggressive approach is imperative and includes exploration, complete thrombectomy and débridement of the vessel, and regional administration of heparin.[8,10,20] Along these lines, fasciotomies were performed routinely in patients with extremity vascular injury. The decision to perform a fasciotomy was based on the duration of ischemia and extensive nature of wounds.

Early graft failures: lessons learned. Although the exact etiology of early graft failure (n = 6) in this cohort was not certain, the most likely cause was a greater extent of vessel injury and thrombus burden than was initially recognized. In some cases, this error in technique resulted in failure to perform a complete thrombectomy and even failure to completely débride the injured segment of vessel. Completion arteriography was neither available nor routinely performed in this experience. Here again, continuous wave Doppler was the tool of choice to assess immediate graft patency.[9]

The two early graft disruptions suggest that the extent of injury to the vessel was underappreciated in these cases, resulting in technical failure of the anastomosis. The remaining two disruptions occurred in poorly covered anastomoses that failed secondary to an infectious process. No deaths were related to acute anastomotic disruption, and one limb was amputated after vessel ligation that was performed to treat a disruption.

Pediatric vascular injuries. The 12 children in the cohort ranged in age from 4 to 17 years, and most of their wounds involved the lower extremity. Our management followed the dictum that blood vessels will continue to grow along with the patient.[21] Therefore, their vascular injuries were managed with the technique of interrupted suture lines using autologous vein. Overall, this group had excellent early outcomes, with all patients having patent grafts and salvaged limbs upon discharge from the hospital.[22] No specific complications were noted in these younger patients, although small vessel size and the propensity for vasospasm offered additional technical challenges.

Study limitations. This study has limitations worth noting. Foremost, detailed data on injury mechanism, precise anatomic location of all vascular injuries, presence of associated injuries, and exact operative technique were not available for some cases in the cohort. This limitation not only reflects the austere conditions in which the registry has been recorded but also the rotation of several surgeons who have contributed cases to the report. In addition, the often-rapid pace of operating (eg, mass casualty events) prevents some details from being immediately and then ultimately recorded. This dilemma is especially challenging in this local population, where events surrounding the injury are often not available because of language barriers.

The second limitation is the lack of long-term follow-up. Although patients did not leave the hospital until all wounds were definitively closed, few patients had more than a single return visit.

Finally, the strategies described in this series have not been compared with other vascular reconstruction and wound management techniques. The austere environment and pace of operating prevented these controlled comparisons. Despite these limitations, the overall observations herein are significant and have not, to our knowledge, been reported in previous wartime experiences.

CONCLUSIONS

This study reports in-theater management of extremity vascular injury in a local population. These injuries present unique challenges related to complex wounds that require complete inpatient management. Despite working in an austere environment, vascular reconstruction using autologous vein and a unique wound management strategy results in a high rate of wound closure and remarkably low rates of infection, amputation, and mortality.

AUTHOR CONTRIBUTIONS

Conception and design: MP, TR, WC
Analysis and interpretation: MP, TR, WC
Data collection: MP, TR, WC, MC, JE, DJ, DS
Writing the article: MP, TR, WC
Critical revision of the article: MP, TR, WC, MC, JE, DJ, DS
Final approval of the article: MP, TR
Statistical analysis: MP, TR, WC
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DISCUSSION

Dr Paul J. Gagne (New York, NY). First, I'd like to commend Dr Peck and Dr Rasmussen on their efforts in Iraq as well as the military medical corps for their efforts. I'd like to thank the authors for giving me a copy of the manuscript well in advance of the meeting. I recommend it to all once it comes out in publication.

This presentation describes a huge experience with extremely complicated vascular wounds with large soft tissue defects related to high-velocity gunshot wounds and IEDs. The authors performed immediate and relatively standard vascular reconstructions with a high success rate. They then débrided these wounds at the time of the initial operation and removed all tissue that was clearly devitalized by the blast injury.

My questions relate more to the soft tissue management than they do to the vascular repair, since these were largely very successful. So you described the débridement at the time of the initial operation and then you used either local soft tissue or flaps to get coverage of your bypass grafts. The first question is, how often did you find on your subsequent débridements that tissue you thought was viable at the time of your initial débridement, and that you used for vascular coverage, turned out to have been injured or compromised by the blast effect? Was it difficult to define, early in your experience, which tissue was viable at the first operation? Did you learn anything over time that allowed you to have better success with your initial débridement and less need for further débridement subsequently?

Also, your infection rate was relatively low, and I am wondering if you can give us some insights, besides débridement and washouts, regarding specific antibiotic regimens as well as the duration of coverage with those antibiotics that you utilized. These were clearly extensive and contaminated wounds.

Finally, are you confident that the blowouts that you had, the four, were infectious? Did they occur early after the vascular repairs or late? Could they have been the result of residual, nondébrided blast injury to the vessel?

Dr Michael A. Peck. First, we aggressively débrided at the time of the initial operation, but I think the learning curve was that we came to understand that we needed to go back to the OR. The goal wasn't to take too much tissue, but it was to take enough that was obviously devitalized at the time, not only of the surrounding soft tissue but also when resecting a blood vessel to then do a repair. So it was better to resect a little bit more blood vessel and do a bypass that was tunneled away from the zone of injury as much as possible.

Point number two was recognizing that the ideal time to go back to the OR was between 24 and 48 hours. This was the point at which marginal tissue declared its viability, and this is why we did all of our care in the OR. We learned this principle early on and tried to pass this knowledge from surgeon to surgeon as we changed over.

Ultimately, after subsequent débridements, it became obvious that the wound was well-granulated and ready either for delayed closure or skin grafting.

As far as the antibiotic usage, we had a negligible incidence in our local population of MRSA. The US forces were evacuated out of theater rapidly, minimizing this incidence. The local population was commonly colonized with strains of *Acinetobacter* that were not multidrug resistant. Imipenem was effective treatment for complicated extremity infections. But it was really the wound débridement and V.A.C. suction dressings that kept the wounds manageable, which I think were the keys to success.

As far as the blowouts are concerned, they all occurred early. They happened while the patients were still in the hospital. And it is unclear whether or not they were due to infection, but it is presumed that they were. It is entirely possible, going back to the original point of resecting adequate amounts of an injured blood vessel, that blowouts may have been due to a breakdown in the vessel itself. And the point to make with this is to understand that blast injuries have a concussive effect and the entire zone of injury may not be fully evident at first. It clearly shows itself 24 hours later.

Dr John Blebea (Philadelphia, Pa). Thank you for a great and interesting presentation. In some ways, it does not seem to be very different from our inner city civilian penetrating trauma population. I am wondering, with such excellent results, do you have any additional information on the medical characteristics of these patients, in other words, their age distribution and associated medical comorbidities? Do they have less of an incidence of diabetes and atherosclerotic disease to get such excellent results?

Secondly, in terms of follow-up, although this is obviously difficult, do you have a standard protocol of trying to get these civilian patients to return and see you at the hospital in order to evaluate long-term outcome and bypass patency, or is that not possible either culturally or administratively because of personnel availability?

Dr Peck. With regard to the patient demographics and their comorbidities, it was really hard to know a patient's real name when they'd come in, but we would ultimately get some of that information. We could easily break it down by gender, and it is roughly 90% male. Most of the patients are young. The median age in Iraq right now is 19. So really, there is not much in the way of an elderly population, although we did have a couple of patients in our experience that were in their 60s. For the most part, these were younger patients who had not yet developed comorbidities. So we were treating young patients with healthy vessels, for the most part. Trauma in the civilian setting would have a similar age distribution.

The follow-up included about 15 days in the hospital, so we had a couple of weeks with all the patients to make sure that they were at least moving in the right direction. Most of the time we were able to see patients a second time for a follow-up visit. Usually, that was about 2 weeks after they were discharged, giving us 30-day follow-up in most cases. Certainly, we lost some patients to follow-up altogether because they were helicoptered to another part of the country upon discharge, having come in as a trauma from that region.

Our follow-up consisted of a wound inspection, a Doppler exam in the clinic, and a chance to instruct the patient to be aware that they had a vascular repair. More than likely, these patients will not have access to a vascular surgeon again unless they are able to come back to the hospital. But we did not have the resources and the structure to do a surveillance program.

Dr Ali F. AbuRahma (Charleston, WVa). Do you think your distribution of injuries is somewhat misleading since you said lower extremities were around 72%, since the majority of these major injuries would never make it to your place? Or did you also include these, in other words, they never made it to you, therefore the distribution might not be appropriate?

Dr Peck. So, to clarify, you are asking is this a realistic distribution?

Dr AbuRahma. Yes.

Dr Peck. This is as realistic of a distribution as we have. These are the patients that came to us. The Iraqi patients, civilians and military, do not wear body armor whereas the US did. And if you look at the US data, both from Vietnam and our current US coalition troops that were treated, they each had about a 90% extremity injury rate, and only about a 10% torso and cervical injury breakdown.

I think it is a realistic distribution in the local population. The three main reasons why we may not be seeing more extremity injuries in the Iraqis are as follows: one, they may have lethal injuries; two, they may have minor injuries which may have a vascular component that is not initially recognized and they don't get taken to our hospital; and three, because of a lack of body armor, they are getting more central injuries.

Dr Jesse A. Blumenthal (New York, NY). Well, I think the distribution was the distribution more or less we had in Vietnam. I'd like to compliment you with your results and I think that it just makes the Vietnam era surgeon a little jealous of some of the equipment you've had.

But the same principles, I think that the thing we learned and transformed into private practice was the frequent débridement and dressing changes in the operating room. And I think that was the thing that way back when probably salvaged more limbs.

And we also learned the hard way is to err on the grafts, taking more artery than less artery, because absolutely the anastomosis must be covered by viable muscle. And if you can't do it initially, then certainly at 48 hours with some type of flap.

And the use of the external fixators is fantastic, because you must have that repair immobile. And certainly the V.A.C. helps. So I think this is closer to what we'd see in a civilian type of arterial trauma population, than strictly military, where you would do the repairs and, unfortunately, evacuate the patients at 7 to 10 days and not get follow-up.

Dr Peck. I appreciate your comments and I think they are very relevant. We used the V.A.C. in the OR because we didn't want to burden the ward nurses and techs with tedious wound care tasks. We also didn't think it was clean. This practice really made things efficient and it also forced us back to the OR, which we learned early on to be beneficial, to continue debriding. It has proven to work for us. Our US troops are evacuated far sooner than yours were, giving us essentially no follow-up.

Dr James M. Salander (Rockville, Md). Who did these repairs? Were these mostly general surgeons? What's the availability of vascular surgeons not only in this hospital but also in in-country overall trained vascular surgeons?

And in each conflict, there is always a learning curve in a broader sense, but as new surgeons arrive in the theater, there is a learning curve for them to get up to speed as to what is going on. It seems as though, looking at your talk and looking at your results, that you seem to have overcome that. And you made some reference to the training of the new surgeons and teaching them the protocols. Give us a little feel for how that is done. Is that done in a formal sense, or is that just done in a buddy system, or how do you do that? How have you created these rather excellent results in a situation that would otherwise predict something else?

Dr Peck. At the Air Force Theater Hospital, we have had a fellowship-trained vascular surgeon consecutively for the last 2 years, changing every 4 to 4.5 months. The entire duration of our experience has been that way.

There are a few other level III facilities in the country, and they may or may not have a board-certified vascular surgeon at any given time. But most patients who are treated at the smaller level II facilities get evacuated to our level III facility, allowing a trained vascular surgeon to evaluate them. A lot of times they would come in with a shunt or another adjunct and we would do the definitive repair. Oftentimes, the definitive repair was already done and it would be re-explored in the OR. So, the overall countrywide presence of a vascular surgeon is sporadic. But at the Air Force Theater Hospital where we are doing all of these definitive repairs, we have and will continue to have a vascular surgeon.

As far as the results and the learning curve, we have a somewhat formal program of making sure that there is about a 1-week overlap when surgeons change over to do some cases together. We have actually put together some PowerPoint lectures that we share with each other, entitled "Lessons Learned." And the moral of the story is "don't try to reinvent the wheel. This is what we've proven to work, and for the most part try to stick with it and avoid your own learning curve."