Moderators' Summary: Wound Management (Session I)

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Extremity war injuries pose several unique treatment challenges compared with civilian extremity trauma. Clinically, the spectrum of injuries encountered in recent conflicts has been skewed toward high-energy injuries associated with improvised explosive devices (IEDs). Advances in field care and evacuation of the wounded combatant have led to more timely arrival in combat surgical hospitals (CSHs), with improved survival. In addition, improvements in body armor are associated with decreased mortality secondary to thoracic, abdominal, and head trauma. As a result of these advances, more combatants are surviving battle injuries than in previous conflicts, but they are incurring severe extremity injuries. In this review of conflict-related extremity trauma, the authors review the evacuation chain, the timing and techniques of wound débridement and coverage, and recommendations for managing retained shrapnel.

Military personnel injured in Iraq and Afghanistan are initially evacuated to Landstuhl Regional Medical Center (LRMC) in Germany. There, as Tenuta reports, wounds are reevaluated on arrival and managed according to type of injury. Patients with multisystem wounds are treated by the general surgery service, while those with severe extremity injuries are treated by an orthopaedic surgeon. From LRMC, patients requiring further treatment are evacuated to the continental United States (CONUS). Comprehensive amputee care in CONUS is provided largely at Walter Reed Army Medical Center and Brooke Army Medical Center.

Given the severity of war-related injuries, early surgical débridement and stabilization have been clinically emphasized. Combatants typically undergo surgical débridement and temporary stabilization in the CSH. Definitive stabilization and soft-tissue coverage procedures are usually reserved for tertiary facilities in Germany (LRMC) and CONUS. The efficacy of this approach, as opposed either to more aggressive resuscitation before surgical débridement and stabilization or to earlier definitive fixation and soft-tissue coverage, is unknown, however, and requires further study.

As noted by Pollak, review of war-related extremity injury literature suggests that the common practice of mandatory surgical débridement of open fracture within 6 hours of injury may not be warranted and that achieving early débridement may pose unjustified risks to the care of injured combatants as well as, potentially, to the surgeons treating them. Further study is needed to elucidate the independent role of timing of surgical débridement on outcome following extremity blast injury. Historically, Bowyer notes, emphasis has been placed on removing nonviable tissue and contaminants and utilizing a thorough and effective débridement technique. The incidence of infection appears to be greater in high-energy wounds than in low-energy wounds, especially blast injuries encountered in combat and secondary to IED-mediated injury.

The literature suggests that early coverage of high-energy open fracture wounds may be superior to de-

layed coverage; however, as Sherman et al note, more controlled studies are necessary. Additionally, because of the nature of combat-related wounds and transport time from theater, early definitive coverage in military scenarios is not always possible. As Kumar discusses, an uncontrolled review suggests that soft-tissue coverage techniques commonly used to manage civilian trauma may be implemented successfully in the treatment of extremity blast wounds. Achieving early coverage in these scenarios has been uncommon, however, given logistics associated with transport to centers technically capable of these advanced interventions. Even with such delays, however, low infection rates have been achieved when soft-tissue reconstructive efforts are done at institutions with appropriate technical expertise. Appropriate patient selection and wound management before reconstruction may contribute to the high success rate with delayed soft-tissue coverage. Achieving a balance between anatomic restoration of bony and soft-tissue injury appears to be important. Close coordination of effort between orthopaedic and plastic surgeons is valuable.

An additional challenge in the management of high-energy blast injuries relates to the indications for fragment removal, as Peyser et al discuss. In the civilian sector, the overwhelming majority of bullet fragments are never removed, with no or few associated consequences. Shrapnel retained after high-energy blast injuries may not behave similarly, however. Long-term consequences of retained shrapnel may be affected by the degree to which the fragments drag dirt, contaminated clothing, or human tissue into the wounds. Reports have also indicated that IEDs laced with feculent material are being used, thus potentially altering the natural history and infection risk associated with retained shrapnel. Historically, the surgical trauma associated with removal of low-energy civilian projectiles was thought to outweigh any potential benefit, given the absence of a demonstrated consequence of retained fragments. Imaging strategies incorporating computer navigation to improve detection, localization, and removal of fragments may significantly decrease the surgical trauma associated with shrapnel removal, resulting in a change in the risk-benefit analysis. Further analysis of the role of fragment removal in the management of high-energy shrapnel injuries is warranted.

No level I and few level II studies exist on which to base clinical decisions. The available studies are further limited in applicability to extremity war injuries in that they involve low-energy civilian injuries. Furthermore, there are no animal models or specific laboratory models available that have effectively addressed questions related to timing and technique of treatment of extremity blast injuries.

A reproducible animal model of blast-mediated extremity injury would be extremely valuable in developing better débridement techniques and improving our understanding of the consequences and treatment of high-energy blast injury. Such a model could enable investigation of the independent effects of débridement techniques as well as the timing of débridement and soft-tissue coverage. Additionally, such a model could serve as a training platform for military surgeons before deployment. Further clinical research is necessary to better understand the effects of timing and technique of both débridement and soft-tissue coverage on outcome following high-energy blast injury.

To facilitate such study, a comprehensive database of information about combatant injury must be developed. Ideally, such a database should be linked to an electronic medical record that follows the injured combatant from the first episode of formal medical care through the entire spectrum of military medical care (including the services provided by the Department of Veterans Affairs) and into the civilian sector. By understanding long-term outcomes and relating them to initial care, valuable information about treatment efficacy can be developed.