MANGLED EXTREMITY

SUMMARY

The mangled extremity, while often not acutely life-threatening, can place the patient at risk for both significant morbidity and mortality. The treating physician must decide if the limb will survive reconstruction with meaningful function afterward, or whether amputation is necessary. The goal should be to improve functional outcome and quality of life for the patient through decreased reperfusion times and clear communication and expectations between all members of the healthcare team.

RECOMMENDATIONS

- **Level 1**
  - **Definitive management of a mangled limb should always be addressed after the patient's life-threatening injuries have been stabilized.**
  - **Patients who are hemodynamically unstable with obvious exsanguination from a mangled extremity should have a tourniquet placed during the primary survey.**
- **Level 2**
  - **Poor prognostic factors for limb salvage include severe multiple injuries [Injury Severity Score (ISS) > 15], high-energy blunt mechanism, shock on presentation (systolic blood pressure < 90 mmHg), markedly positive fluid balance in the first 24 hours post-injury (> 3 liters of crystalloid), and associated traumatic brain injury.**
  - **Computed tomography angiography (CTA) should be performed in the hemodynamically stable patient, without hard signs of vascular injury that would warrant urgent operative management, to define the injury and vascular supply. If CTA is unavailable, traditional angiography should be performed or the patient transferred to an appropriate center.**
  - **Neurologic exam should only act as an adjunct to guide management as traumatic neuropraxia may be temporary in the early hours following injury.**
  - **When amputation is deemed necessary, immediate rather than delayed amputation is preferred and should be performed at the most distal level possible based on tissue viability, while avoiding amputation through a joint.**
- **Level 3**
  - **A limb attached by only marginal amounts of subcutaneous tissue and/or skin should be amputated as attempts at salvage will be futile.**
  - **A limb with a warm ischemia time greater than 6 hours is unlikely to survive attempts at salvage and should be amputated. However, a limb with less than 6 hours warm ischemia or no more than 24 hours of cold ischemia may be salvageable if otherwise deemed appropriate for reconstruction.**
  - **Scoring systems should be used as a tool, but not an absolute indication for amputation or salvage in the mangled extremity.**

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

INTRODUCTION

A “mangled extremity” is defined by the Western Trauma Association (1) as “any extremity sustaining sufficiently severe injury to a combination of vascular, bony, soft tissue and/or nerve structure that results in subsequent concern for viability of the limb.” Deciding when to salvage or amputate a mangled extremity can be a difficult decision for the trauma surgeon. Scoring systems and decision-making algorithms have been developed, but are based solely on retrospective data from small samples that have not proven valid when applied prospectively (2). Advances in limb reconstruction techniques and technology have made the decision even more difficult as the once clearly non-viable mangled extremity may now have a chance to be salvaged (3). Despite these advances, management decisions rely heavily on the available resources and expertise of the physicians involved.

LITERATURE REVIEW

Initial Trauma Evaluation and Management

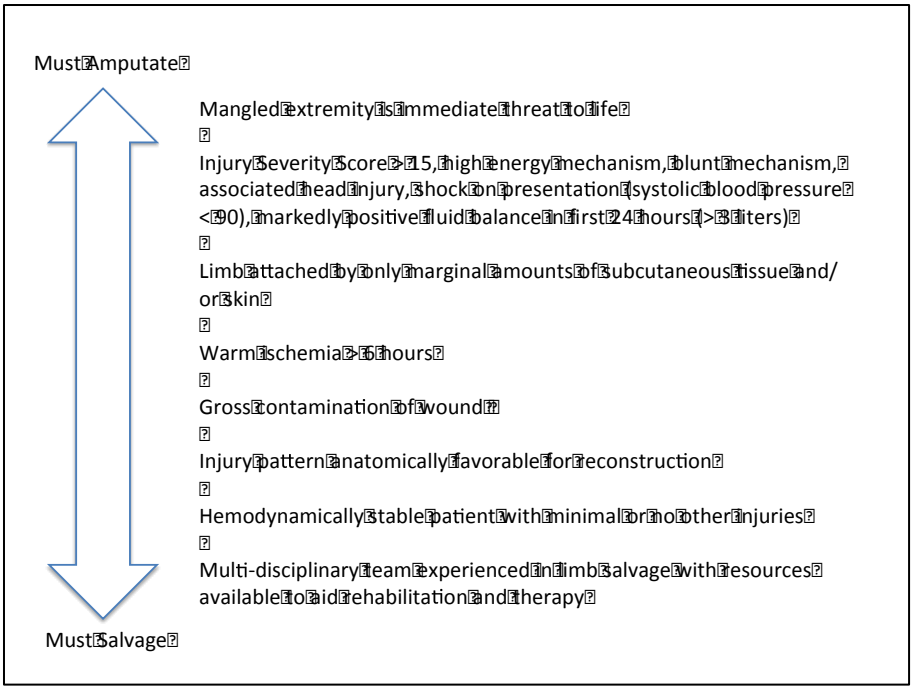
The Primary Survey of the Advanced Trauma Life Support (ATLS) algorithm was designed to address immediately life-threatening problems and a mangled extremity can be very distracting during this assessment. As Scalea et al. have stated, “An ischemic limb does not represent an immediate threat to life [and] it is a common pitfall, among inexperienced providers, to reach for the Doppler probe to assess distal perfusion as part of the primary survey.” (1) . While an ischemic limb is not an immediate threat to life, an exsanguinating limb is. A hypotensive patient that is bleeding excessively from an injured limb should have a tourniquet applied rapidly. If airway and breathing can be addressed expeditiously, then the exsanguinating mangled limb can be addressed during the assessment of the patient’s circulation. If not, a tourniquet should be applied even before full control of the airway, or, ideally with adequate help, simultaneously. If exsanguination is not occurring, it is imperative to wait until the Secondary Survey to address the mangled extremity.

Scoring Systems for Management of the Mangled Extremity

Multiple scoring systems have been developed with the goal of predicting the need for amputation, but none have proved valid prospectively (2,4-6). The Predictive Scoring Index (PSI) was the first such system developed to predict amputation after lower extremity trauma (7). Howe et al. performed a retrospective review of 21 injured limbs to create a scoring system based on the degree of osseous injury, muscular injury, arterial injury and warm ischemia time. The scoring system was 78% sensitive and 100% specific in predicting lower extremity amputation. This was followed by the Mangled Extremity Scoring System (MESS) which used the degree of skeletal and soft tissue injury, limb ischemia, shock (systolic blood pressure < 90mmHg) and patient age (8). A score greater than seven was 100% accurate at predicting amputation in retrospective analysis and a prospective trial of 26 limbs. The Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age of Patient Score (NISSA) was created out of a retrospective analysis of the MESS (9). McNamara et al. found that by separating skeletal and soft tissue scores and adding nerve injury to the scoring system, they improved both sensitivity and specificity. Russell et al. developed the Limb Salvage Index (LSI) independent of the MESS using the degree of arterial, osseous, nervous, cutaneous, muscular, and deep venous injury, as well as warm ischemia time (10). They did not find patient age or shock to have a significant impact on predicting amputation. In retrospective analysis, all patients with a LSI score less than 6 had successful limb salvage and all those greater than 6 required amputation. Further prospective studies showed that all of these scoring systems have a high specificity for predicting limb salvage potential when scores were low, but they were not sensitive in predicting amputation (4). Additionally, these scoring systems did not follow clinical or functional outcomes. When these outcomes were assessed, the scoring systems were not found to be valid predictors of limb functionality or clinical outcome (2).

Indications for Early Amputation

There are situations when it appropriate to immediately amputate. These include extremities that are attached by only marginal amounts of soft tissue, to control exsanguination and to prevent a crush syndrome in a multiply injured patient that will not likely survive the additional insult (1,6). Furthermore, evidence supports early amputation is preferred to delayed as the latter group typically experiences longer hospital stays with more complications (11).



According to data from the National Trauma Database (NTDB), shock in the trauma bay, severe head injury, ISS > 15, specific limb injury types, and high energy mechanism were all associated with higher rates of early amputation. Early amputation was defined as amputation occurring by the end of the first full calendar day following presentation. Limb injury characteristics including crush injuries above the knee had early amputation rates significantly higher than penetrating injuries occurring below the knee. Additionally, injuries involving subcutaneous tissue, arteries and nerves had significantly higher rates of early amputation than injuries including just one or two of the described structures (12). The findings from de Mestral et al. are consistent with many of the poor prognostic indicators in the various scoring systems listed above. Age, which is an integral aspect of the Mangled Extremity Scoring System, was not found to be associated with early amputation.

Overall injury burden should be included in the decision to amputate versus attempt limb salvage. In cases where there are severe multiple injuries, an extremity that may be salvageable as a single injury may require amputation if the limb represents additional injury burden beyond what the patient can tolerate. In these cases, primary amputation allows the operative team to move past the mangled extremity and concentrate on other life-threatening injuries. These cases represent a “life versus limb” scenario and close consultation between the surgical team and anesthesia team should take place. Prolonged time in the operating room while performing limb salvage with a patient requiring aggressive resuscitation can lead to poor overall patient outcomes (1). Additionally, a markedly positive fluid balance (>3 liters) is an indicator of systemic compromise and a poor prognostic factor for successful limb salvage (13).

The neurological exam should act as an important adjunct to evaluating the mangled extremity recognizing that lower extremity neurological deficits may not be reliable in the acute setting (2). Using the neurological exam as a determining factor for amputation came from the NISSA scoring system (9). This method included neurological findings as part of the scoring system and places the most weight on plantar sensation. The LEAP study demonstrated prospectively, however, that peripheral nerve deficits are not sensitive predictors of successful limb salvage. There are many instances where neurologic deficits in the acute phase after injury represent neuropraxia rather than complete nerve loss. Relying on this finding could lead to unnecessary amputation. Rather than use the neurological exam for immediate treatment decisions at time of patient presentation, it should be used to track healing and recovery of limbs undergoing reconstruction.

Amputation and the Importance of Avoiding Delay

After the decision has been made to amputate, the limb should be amputated at the most distal level possible without including obvious non-viable tissue. Color, consistency, contractility and bleeding of soft tissues should be used to determine the tissue viability. The extremity should be thoroughly irrigated and debrided and a sterile or negative pressure dressing should be applied as well as a splint if the amputation is carried out below the level of the knee (3). More distal amputations have been shown to have better functional outcomes as well as decreased energy expenditure compared to more proximal amputations (14).

The decision to salvage a mangled extremity or amputate is difficult, but delays increase the risk of complications. Wound infection and non-union are the two most common complications following severe lower extremity trauma (15). Of the patients undergoing amputation, regardless of initial mangled extremity score, those whose amputation occurred >48 hours after initial injury had much higher rates of local wound complications and longer length of stay (11).

Limb Salvage

Advancing technology and operative techniques have allowed for endeavors into limb salvage that may have never been attempted in the past. The initial approach to limb salvage should be methodical. Once the patient is stabilized with respect to the primary survey and additional injuries assessed in the secondary survey, he or she should be taken to the OR for thorough irrigation and wound debridement (3). All non-viable tissue should be excised and damage control orthopedics performed with reduction of fractured bones and placement of external fixators. Other temporizing measures may be employed to include vascular shunts and fasciotomies. Prophylactic antibiotics should be given at this stage. The patient should be taken back at 24 and 36 hours for repeat wash-out and debridement. A multi-disciplinary team to include vascular, plastics and/or orthopedics will likely need to be involved for planning of reconstruction. The trauma surgeon acts as the coordinating provider in this setting and should be constantly reassessing the limb for viability. If at any point, the limb appears to be non-viable, amputation should be considered. If the limb becomes a threat to the patient's life, there should be no hesitation to amputate.

Despite our advancing ability to salvage limbs, to do so may not always provide the patient with the best outcome. Limb salvage subjects the patient to multiple operations, lengthy hospital stays and exorbitant medical costs that personal health insurance may not fully cover. Furthermore, these patients often complain of chronic pain and difficulty with function (16). However, just as the technology and techniques for limb salvage have advanced, so has prosthetic technology. Patients can now achieve a nearly complete pre-injury level of functioning, specifically with lower extremity amputation. Hoogendorn found that patients undergoing limb salvage had more hospitalizations and complications (17). However, the LEAP study evaluated long-term effects and functional outcomes between limb salvage and amputation finding no significant difference in functionality between the groups (4). It is worth noting that both groups did define themselves as equally having severe disability. Multivariate analysis from this study revealed poor predictors of functional outcome for limb salvage included; re-hospitalization for a major complication, education below a high school level, low socioeconomic status, being non-white, having poor insurance and smoking. Interestingly, the highest predictors of poor functional outcome were low self-efficacy and lack of a strong social support system (18). This demonstrates that when limb salvage is possible from a technical standpoint, many additional patient factors need to be considered in order to afford the patient with the best possible outcome and psychosocial services should be provided early on in the treatment course.

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