Patients with a mangled extremity, defined as a limb with an injury to at least three out of four systems (soft tissue, bone, nerves, and vessels) represent a high-risk patient population requiring expedient care to salvage life and limb. Prompt re-establishment of vascular integrity and fracture stabilization is imperative. The coordination of multiple surgical services (Trauma, Orthopedic, Vascular, and Plastics) to expedite care is paramount for optimal outcome and is the responsibility of the Trauma Service. These patients frequently have multi-system and life threatening injuries and balancing these issues is extremely important.

Emergency Department Evaluation

- Initial patient evaluation follows ATLS
- Application of tourniquet proximal to the injury is indicated with active hemorrhage or hemodynamic instability
- Evaluation of limb perfusion is performed after patient stabilization and gross limb realignment
- Level 1 trauma activation and upgrade criteria include:
  - mangled extremity proximal to the wrist or ankle
  - pulseless extremity following immediate fracture reduction
  - SBP < 90 OR HR > 120
  - patient receiving blood transfusion
  - patient requiring tourniquet
- Any extremity with suspected vascular injury (asymmetric pulse or ABI < 0.9) should prompt immediate TRAUMA SERVICE consultation via the trauma chief phone (x47055)
- Fractures should be reduced and immobilized immediately following evaluation and stabilization
- Patients with suspected open fractures should receive cefazolin/tetanus prior to radiographic confirmation
- Patients with hard signs of vascular injury or hemodynamic instability are taken directly to the OR (general trauma OR, not HVI) for exploration and/or angiogram. Hard signs of vascular injury include:
  - active pulsatile hemorrhage
  - pulsatile or expanding hematoma
  - palpable thrill or audible bruit
  - limb ischemia
  - absent pulse following fracture reduction
- Patients without hard signs of vascular injury or hemodynamic instability will have a complete secondary survey performed, with special attention to joint stability and ABIs
- Patients will be examined in the ED by Trauma and Orthopedic services
- Indications for CTA:
  - Hemodynaimically stable patients with BBI or ABI < 0.9
  - Hemodynamically stable patients with BBI or ABI > 0.9 and unstable knee or high risk fracture may have CTA at the discretion of the trauma chief resident or the treating faculty involved in the case (EM, Trauma, Ortho, Vascular)
  - high risk fracture pattern and inability to perform ABI or BBI
• Patients requiring immediate operative intervention will be taken to the general trauma OR by the Trauma service with Orthopedic Surgery
• Vascular Surgery and Plastic Surgery will be consulted at the discretion of the Trauma Attending
• Patient is admitted to the Trauma Service

Operating Room

All emergency operations will be performed in the General Trauma OR, not HVI OR

Limb salvage versus amputation

Current injury severity scoring systems, specifically the Predictive Salvage Index (PSI) and Mangled Extremity Severity Score (MESS), for mangled extremities do not predict functional recovery of patients who undergo successful limb reconstruction. Limb salvage should be attempted if the other injuries are minimal, the patient is hemodynamically stable and the extremity injuries are amendable to salvage. The involved faculty should have a brief but focused discussion in the OR regarding priorities of care.

Indications for early amputation (any of the following):
• Hemodynamic and physiologic instability secondary to complex injured extremity as determined by Trauma surgery faculty, i.e. “life over limb”
• Un-reconstructable osseous injuries as determined by Orthopedic surgery faculty
• Un-reconstructable soft tissue injuries as determined by Plastic Surgery faculty
• Irreparable vascular injuries as determined by Vascular or Trauma Surgery faculty
• Severe loss of soft tissue

Indications for limb salvage:
• All other patients not meeting above criteria

Unstable fracture with vascular injury – operative sequence

The optimal sequence of events (definitive vascular repair before or after damage control orthopedic fixation) is controversial and is based on several factors such as ischemic time, degree of soft tissue damage, degree of fracture instability, and ultimately, surgeon preference and operative efficiency. Despite multiple retrospective studies, no definitive standard of care exists. Surgical care should be individualized and determined by a multi-disciplinary discussion with involved faculty.

For patients with unknown or prolonged ischemic time and unstable, contaminated open fractures, a safe surgical sequence of events is:

Shunt → Ex-Fix → Fasciotomy → soft tissue debridement → definitive vascular repair

This approach will minimize ischemic time and allow fracture fixation and aggressive soft tissue debridement to allow appropriate determination of limb salvageability prior to performing a prolonged definitive vascular repair.
Temporary intravascular shunt (TIV) versus definitive vascular repair

Indwelling TIV for damage control:
- hemodynamically unstable patient with unfavorable physiology (the lethal triad)
- poly-trauma patient with multiple extremity and torso injuries
  - these patients are better served by on-going resuscitation in the ICU rather than a lengthy vascular procedure
  - systemic anticoagulation is generally not necessary
  - definitive vascular repair should be done after stabilization and ideally within 24 hours
  - ideal anatomic location for shunt placement is proximal to the elbow and knee

TIV prior to definitive vascular repair at same operation:
- prolonged ischemic time prior to arrival to OR
- unstable fracture in need of orthopedic stabilization prior to vascular repair
- contaminated extremity with need for aggressive soft tissue debridement
- allow time for Plastic surgery and orthopedic surgery to assess limb salvageability

Indications for fasciotomy

Since it is common to underestimate the time from injury to restoration of blood flow, by default, all complicated extremity injuries will receive a complete fasciotomy unless all involved faculty members believe the fasciotomy is unnecessary based on known ischemic time and physiology. Fasciotomy prior to definitive vascular repair should be considered to optimize venous outflow and decrease ischemic time.

Absolute indications for fasciotomy:
- ischemic time of 4-6 hours
- compartment syndrome unequivocally diagnosed on physical exam
- $\Delta p < 30$ mmHg ($\Delta p =$ diastolic blood pressure – compartment pressure)
- compartment pressure > 25 mmHg
- unknown ischemic time

Relative indications for fasciotomy:
- combined skeletal and vascular trauma
- ischemic vascular injury associated with shock
- combined arterial and venous injury
- crush injury

Post-operative care

Post-operative care will primarily be provided by the Trauma Service or the STICU team.
SERVICE RESPONSIBILITIES

Trauma Surgery
Coordinate and expedite care of all specialty services
Admit the patient and provide post-operative care
Perform fasciotomies when indicated in extremities without fractures or dislocations
Wound care when a free flap is not required
Amputations when indicated
Skin grafts when flap coverage is not required

Orthopedic Surgery
Provide damage control extremity fixation
Perform fasciotomies when indicated in extremities with fractures or dislocations
Provide definitive long bone stabilization

Vascular Surgery
Assist trauma surgery with damage control vascular procedures (shunts) if needed
Assist trauma with definitive vascular procedures if needed

Plastic Surgery
Provide definitive soft tissue coverage when flaps are necessary
Provide definitive soft tissue coverage if fractures or dislocations are involved
References


