Management of Complex Extremity Trauma

AD HOC COMMITTEE ON OUTCOMES

Due to the combination of soft tissue, osseous, vascular, and nerve involvement, complex extremity trauma requires prompt and precise evaluation and management to attain optimal outcome. Patients sustaining these unique injuries are at high risk for ischemia, wound infection, delayed union or nonunion, and chronic pain, not only owing to the anatomy of their injuries, but also the prevalence of associated multisystem trauma and systemic problems related to the mechanism of injury. While the treatment goal remains extremity salvage, these injuries carry a high potential for morbidity and amputation.

Unfortunately, the data regarding the management of complex extremity trauma are conflicting, and Class I studies are lacking. In an effort to provide guidance and a rational approach to the initial evaluation and treatment of complex extremity trauma, the Ad Hoc Committee on Outcomes of the American College of Surgeons Committee on Trauma has combined recommendations based on the best available evidence with expert consensus in preparing this protocol. This document provides an annotated algorithm describing an approach to complex penetrating and blunt extremity trauma that is supplemented by the Eastern Association for the Surgery of Trauma (EAST) Practice Management Guidelines for Penetrating Trauma to the Lower Extremity.*

* The EAST Practice Management Guidelines for Penetrating Trauma to the Lower Extremity provide more detailed discussion on both arterial and venous injuries and can be found online at *www.EAST.org*.

1. Resuscitation and management of all life-threatening injuries must take priority over any extremity problems. Only active extremity hemorrhage must be controlled at this time by direct pressure, tourniquet, or direct clamping of visible vessels (in that order of preference) as a life-saving measure. Blind clamping in wounds is discouraged and potentially harmful to limb salvage.

   Once attention is directed to the extremity, neurovascular injury should be assumed in all injured extremities until definitively excluded as the first diagnostic priority. Vascular injury ideally will be found and treated within 6 hours to maximize the chance of limb salvage, as it is the major determinant of limb salvage.

2. Risk factors for amputation[†]:

   - Gustilo III-C injuries—comminuted, open tibial-fibular fractures with vascular disruption
   - Sciatic or tibial nerve, or 2 of the 3 upper extremity nerves, anatomically transected
   - Prolonged ischemia (>4–6 hours)/muscle necrosis
   - Crush or destructive soft tissue injury
   - Significant wound contamination
   - Multiple/severely comminuted fractures/segmental bone loss
   - Old age/severe comorbidity
   - Lower versus upper extremity
   - Apparent futility of revascularization/failed revascularization

   [†] These factors have been applied over the course of the past 2 decades in several scoring systems to predict primary amputation. Although the scoring systems have validated these factors to be associated with a worse prognosis for limb salvage, none have adequate prospective reliability to permit a definitive decision for amputation to be made based on a score alone.

3. If early amputation is deemed necessary, it should be performed at an appropriate level above the destructive wound without attempting to close the wound at this time. Photographs may be useful to document severity of injury prior to amputation. Marginally viable soft tissue should be preserved and the open wound copiously irrigated and debrided of contaminating debris. The amputation stump should be dressed with a bulky absorbent dressing and protective splint if amputation is below the knee and/or elbow. Early return to the operating room for further wound debridement and definitive management should be anticipated.

   If the need for amputation is not clear on initial presentation, limb salvage should be attempted and the extremity observed carefully for the next 24–48 hours for soft tissue viability, skeletal stability, and sensorimotor function.

4. Hard signs of vascular injury include:

   - Active hemorrhage
   - Large, expanding, or pulsatile hematoma
   - Bruit or thrill over the wound(s)
   - Absent palpable pulses distally
   - Distal ischemic manifestations (pain, pallor, paralysis, paresthesias, poikilothermy, or coolness)

5. The liberal use of imaging in the presence of any hard sign to confirm or exclude vascular injury is recommended. Most hard signs in this setting (as much as 87%) are NOT due to vascular injury, but rather to soft tissue and bone bleeding, traction of intact arteries with pulse loss, or compartment syndrome. When imaging is not possible, immediate surgical exploration of the vessel at risk should be considered. If these measures exclude surgically significant vascular injury (such as no occlusion, extravasation, or transection), the treatment of soft tissue and skeletal injuries may proceed. How reperfusion is achieved depends on the patient's hemodynamic status, physiologic parameters, skeletal stability, wound characteristics, and resource availability.

6. There should be low threshold to perform a 2-incision, 4-compartment fasciotomy of the distal extremity in complex extremity trauma at the time of initial revascularization because of the high risk of compartment syndrome. If fasciotomy is not performed immediately, observation should include frequent direct measurement of compartment pressures owing to the poor sensitivity of clinical examination for the presence of compartment syndrome.

7a. A definitive vascular repair should be avoided, and there should be consideration for placement of a temporary intraluminal shunt in the proximal and distal ends of the injured vessel after distal thrombectomy and regional or systemic heparinization (if not contraindicated) in the following settings:

- Hemodynamic instability, coagulopathy, acidosis, hypothermia of the patient
- Unstable skeleton
- Major wound contamination/infection or soft tissue deficits precluding wound coverage
- Requirement for any definitive repair more complex than lateral suture or end-to-end anastomosis (such as extraanatomic bypass, interposition graft)
- Austere environment with no resources for definitive management
- Other life-threatening injuries requiring urgent management

If tourniquet control or ligation of injured extremity vessels is the only means of controlling life-threatening hemorrhage and reperfusion is not possible because of the nature of the wound or the environment, then immediate evacuation is necessary to achieve revascularization within 6 hours if limb salvage is to be attempted.

7b. A definitive vascular repair should be considered in the following settings:

- Hemodynamic and physiologic stability of the patient
- Stable skeleton
- Clean wound with adequate viable soft tissue
- Availability of necessary time and resources
- No other injuries requiring more urgent management

8. Many commercial plastic intraluminal shunts are available. However, plastic intravenous tubing or connecting tubing that accompanies many closed suction drains is sufficient if irrigated with heparinized saline before use. The ends of the tubing should be placed in the proximal and distal segments of the injured artery, secured by a silk suture tied around the vessel over the shunt, and then also tied directly on the shunt itself to prevent dislodgment. Alternatively, shunt clamps can be used to clamp the vessel over the shunt. Flow through the shunt should be monitored regularly by palpating distal arterial pulsation and/or using a Doppler device to detect flow signals through the shunt or distal vessel. If flow ceases, the shunt and distal vessel must be thrombectomized with a Fogarty catheter and reinserted. If not contraindicated, systemic heparinization may facilitate shunt flow.

9. Skeletal stabilization by splint or external fixation should be considered after reperfusion in those settings found in item 7a. Definitive internal fixation of skeletal extremity injuries should be delayed until conditions in item 7b are reached, and after definitive vascular repair is performed.

10. The absence of any hard sign in an injured extremity excludes a surgically significant vascular injury as reliably as any imaging modality. If all hard signs are absent, no vascular imaging or exploration is necessary, and treatment of skeletal and soft tissue injuries may proceed.

11. Wounds should be inspected frequently and any dead/necrotic tissue should be debrided and dressings changed accordingly.

12. Amputation after initial attempts at limb salvage should be considered if risk factors for limb loss persist. However, the patient's family, as well as involved surgical specialists, should be informed and involved in this decision whenever possible. In limbs that ultimately will be without function, excessive attempts at salvage should be avoided. Any adverse impact of the extremity on the patient's health, such as sepsis, rhabdomyolysis, hyperkalemia, ARDS, or other life-threatening problems, should lead to consideration of immediate secondary amputation.

13. Continue limb salvage efforts, and monitor the patient closely for changes that may warrant secondary amputation.

Prognostic Factors for Limb Salvage Following Complex Extremity Trauma

A. Time

There is a linear and direct correlation between delay in revascularization and limb loss.

B. Mechanism

Blunt or high-velocity penetrating trauma has a worse outcome than simple, low-velocity penetrating trauma.

C. Anatomy

Lower extremity vessels have worse prognosis of salvage than upper extremity vessels; the popliteal artery has the overall single worst prognosis for salvage.

D. Associated Injuries

E. Age and Physiologic Health

F. Clinical Presentation

Shock and obvious limb ischemia pose worse outcome than warm distal tissue in a stable patient.

G. Environmental Circumstance

Forward combat zone, austere environment, and multicasualty events may warrant primary amputation as a logistic necessity.

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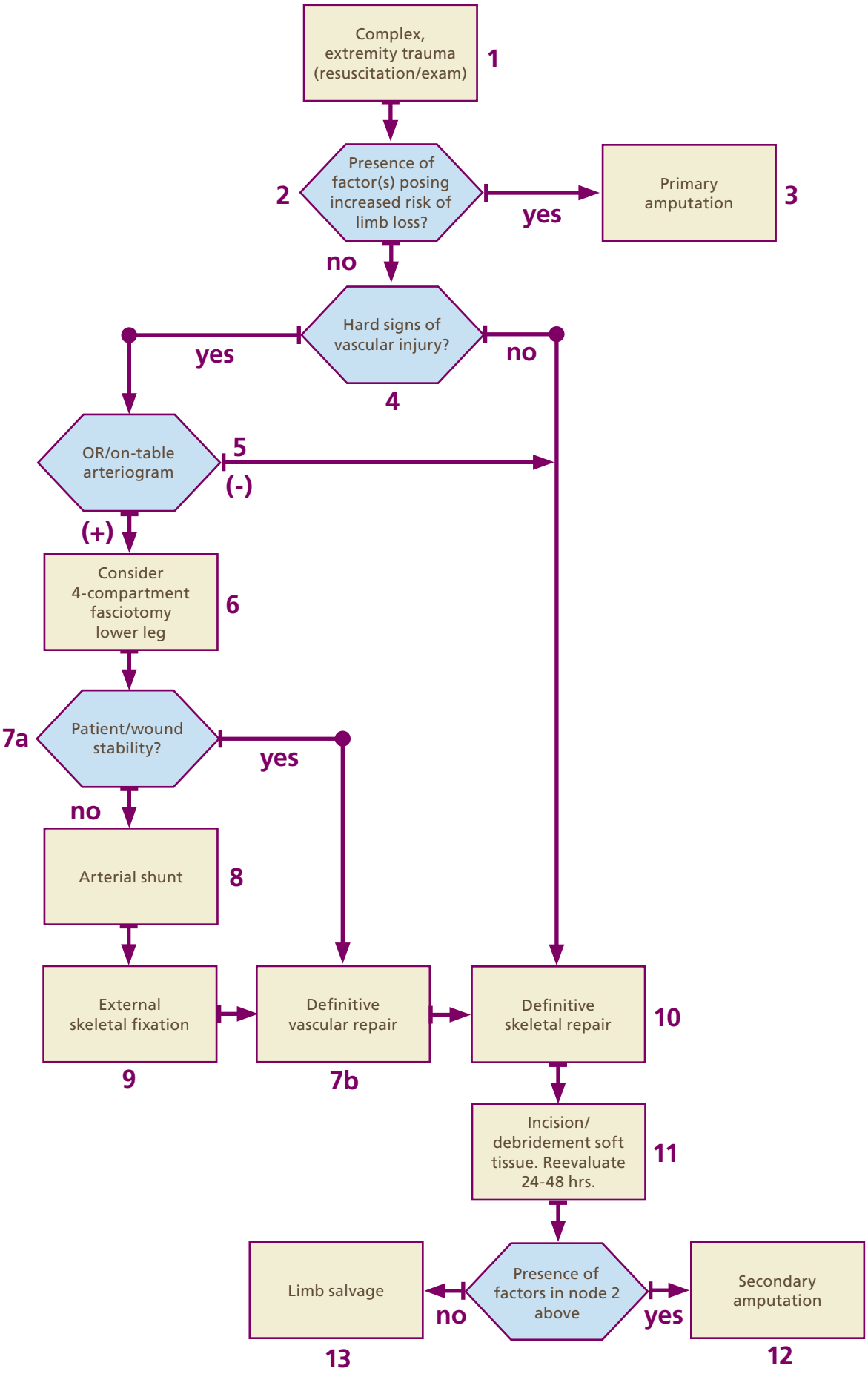

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