

### Trauma Service Guidelines

<b>Title:</b>	<b>Mangled Limb Guideline</b>
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### Purpose

The purpose of this guideline is to assist in the assessment and management of patients with massive extremity trauma. It has been based on the best available evidence for the early recognition, resuscitation and management of the mangled lower limb, it ensures the multidisciplinary team is involved from admission to discharge and are included in the decision making for these patients. The principles in this document apply to both upper and lower limbs.

### Background

Mangled limbs pose immediate and complex decision-making challenges; they involve multiple systems, and require a multidisciplinary approach including Plastic Surgery, vascular, trauma and orthopaedics.

Injuries that result in extensive bone comminution, skin degloving, muscle damage and disrupted soft tissues planes usually result from a high force mechanism. These injuries are often accompanied by significant chest, abdomen and pelvic injuries, which are more likely to be immediately life threatening.<sup>1-5</sup>

### Definitions:

For the purpose of this guideline, a mangled extremity is defined as:

- Any extremity which has sustained an injury to a combination of vascular, bony, soft tissue and/ or nerves, vessels that results in subsequent concern for the viability of the limb.<sup>1, 6-10</sup>  
and/or
- Injury to 3 out of the 4 systems (soft tissue, bone, nerves and vessels).<sup>2, 11</sup>

Early amputation is defined as occurring on the initial surgical procedure, whereas delayed amputation is at a subsequent procedure.

### Initial Management

Priorities in the initial assessment of the patient with a mangled limb include recognition and early management of life threatening injuries as per EMST guidelines<sup>5</sup>. These threats could be from major haemorrhage, from the extremity itself or<sup>5</sup> due to concomitant injury to the head/neck/torso.

As a component of the ABCDE's, initial management should include control of external blood loss by direct pressure. Tourniquets should only be used in life threatening limb haemorrhage that cannot be controlled with direct pressure. If required, place the tourniquet (or wide 5cm bandage) 5-7cm above the bleeding point and tighten until circulation to injured limb is stopped. Clear documentation of application time in the medical record and on the patient or tourniquet.<sup>12 13, 14</sup> Consideration should be given to where and when the tourniquet should be removed, and frequent inspections 'to see of there is still bleeding' is to be discouraged. Protruding embedded objects should not be removed in the emergency department unless presenting an imminent threat to staff safety.

Fractured bones should be splinted or external fixation applied. This will assist in haemorrhage control, improve perfusion facilitating better assessment of soft tissue and bony abnormalities and reduce pain.<sup>7, 9</sup>

See [TRM08.12 Traumatic Cardiac Arrest Guideline](#) and [TRM08.01 Massive Blood Transfusion in Trauma guideline](#) for the management of the haemodynamically unstable patient.

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### Clinical Assessment of the Mangled Limb

Once multitrauma assessment is complete and stability is gained, full assessment of the mangled extremity should be performed and should include;

- (1) Vascular assessment, clinical assessment of potential or actual ischemia, +/- doppler's & CT Angiography.
- (2) Skeletal assessment, both clinical and radiologically.
- (3) Neurological assessment, i.e. sensory and motor loss, complete or partial with particular attention to height of injury.
- (4) Soft tissue; degree of deficit.
- (5) The presence and effect of any placed tourniquet.

All four specialities (plastic surgery, orthopaedic surgery, vascular surgery and trauma) should be notified once a patient with a mangled extremity is identified in the Emergency Department. It is not an expectation that all services attend immediately in all patients, but rather each specialty is given the opportunity to be involved if the particular injury pattern requires it. Surgeons should be mindful that procedures performed by one specialty may impact upon the planned procedures from another specialty.

The patient should be initially admitted under the Trauma Service, who are responsible for 'whole of patient' assessment which may involve balancing the risks of ongoing limb salvage efforts versus patient survival, in a collaborative manner. Subsequent management is on a negotiated case by case basis, but likely to be driven by a combined orthoplastic team, who should manage the patient in unison rather than sequentially.

### Decision Making: Amputation versus Limb Salvage

Early decision making in the management of a mangled limb aims to decide whether primary amputation or limb salvage is the best option. The objectives of treatment are to manage the soft tissue injury, minimise the risk of infection, stabilise and repair the skeletal injury and restore the function of the affected extremity if possible.<sup>8,15</sup>

Such decisions are complex and should involve multidisciplinary input from Trauma, Orthopaedic, Plastic and Vascular Surgery on a case by case basis. Major management decisions by isolated specialties is to be discouraged: one specialties' decision often affects another's. Any decision to amputate should ideally be taken by two consultants directly involved in the patient's care.

#### Multidisciplinary meeting for mangled extremity

An informal meeting of attending senior surgical staff (e.g. Trauma, Plastic and Orthopaedic surgery) can be arranged by the trauma service if any of the treating team feel it is warranted. This may be applicable if the case is particularly complex, or if there is a lack of consensus about management. Please contact the Trauma Clinical Nurse Consultant (page 746) or Trauma Surgeon of the day via switch.

#### **Decision making**

Consideration should be given to:<sup>1,7,9-11</sup>

- (1) Pre-injury health status (comorbidities and functional status).
- (2) Injury factors (location and severity of mangled extremity, wound contamination).
- (3) Associated injuries.
- (4) Physiologic severity of illness.
- (5) Patient preference and available personnel and resources.

#### Pre-injury health status and patient considerations

The loss of a limb presents a significant ongoing psychological, functional and lifestyle burden for patients. Early communication with the patient and family should be considered where possible to include them in the decision making process.<sup>7,9</sup>

Limb salvage should only be attempted in those patients with adequate physiologic reserve and when there is a reasonable expectation that the limb is salvageable, with meaningful functional outcome<sup>8,11</sup>.

Limb salvage can subject the patient to multiple operations, increased length of stay, increased morbidity and mortality and medical costs. Chronic pain and loss of function are common ongoing concerns for patients after limb salvage.<sup>8</sup>

### Injury factors

Injury factors that may impact on decision-making include limb specific factors and other injury factors. An example of the latter is a severe head injury may make it unlikely that the limb is used even if salvage is successful, noting that such prognostication can be difficult.

Limb factors: The extent of injury including fracture pattern, level of vascular injury, warm ischemia time, soft tissue injury and the grade of nerve injury (neuropraxia, axonotmesis, neurotmesis), the status of the ipsilateral and the contralateral limb are important factors to consider.<sup>7, 11, 16, 17</sup>

Vascular damage should be assessed and ischaemic time identified after resuscitation and bone stabilisation has been established. If the pulse is not palpable or weak, a Doppler assessment should be undertaken and vascular consultation requested. If a patient demonstrates the 'hard signs' of vascular injury i.e. active haemorrhage, rapidly expanding haematoma, absent pulses or palpable thrill/bruit, in consultation with the Vascular Surgeon, the patient should be considered for immediate management in the operating room without diagnostics.<sup>1, 8, 18</sup> Vascular injuries to peripheral vessels (e.g. Brachial, Radial, Ulnar, Superficial femoral, Peroneal and Tibial) involving damage to adjacent structures such as nerves, tendons and with associated compound tissue loss likely to require flap coverage, may at times be best managed by the Plastic Surgery unit alone.

CT Angiogram (CTA) of limb has demonstrated a sensitivity and specificity rate equivalent to angiography in patients with arterial injury.<sup>18</sup> CTA is readily available and non-invasive and is recommended as the primary imaging modality to assess arterial injury in lower extremity injury,<sup>18</sup> if the patient's clinical state allows it.

A neurologic examination using the ASIA chart available on EMR of the extremity to assess peripheral nerve function should be conducted. Poor outcomes have been associated particularly with injuries at or proximal to the tibial nerve especially with high grade injuries<sup>7</sup> and in proximal (above elbow) injuries of the median, ulnar and radial nerves.

Soft tissue loss, contamination and the degree of debridement required can also influence the decision to salvage or amputate. Circumferential tissue loss is less attractive to salvage as more soft tissue is required for coverage and the salvaged distal limb is prone to lymphoedema.<sup>7, 9</sup> An amputated limb should be considered as a potential donor site for the reconstruction of other coexisting injuries and hence should not be removed and / or discarded to Pathology without consultation with the Plastic Surgery Unit as "spare part" surgery is an elegant way to not only replace "like with like" but also to reduce further donor site morbidity.

### **Scoring Systems**

Scoring systems and decision making algorithms have been developed such as Mangled Extremity Severity Score (MESS). These can be utilised to assist in decision making but are not a substitute for clinical judgement. **MESS** consists of four domains, which consider the degree of skeletal and soft tissue injury, limb ischemia, shock and age (table 1). On initial validation a MESS score > 7 was 100% predictive of amputation.<sup>7</sup> However these results are based on retrospective data from small samples that have not proven valid when applied prospectively in larger populations.<sup>7-9, 17</sup> **LEAP** (Lower Extremity Assessment Project) also found that scoring systems do not predict patient functional recovery for those that have undergone successful limb reconstruction.<sup>7, 16</sup>

### **Immediate Amputation**

Immediate amputation may be indicated in the haemodynamically unstable patient (life over limb), in extremities that are attached only by marginal amounts of soft tissue and to prevent a crush syndrome in a multi-trauma patient.<sup>8</sup> Ideally, such a decision should be made by at least two Consultants specialties (Orthopaedics, Vascular, Plastics, Trauma) who are directly involved in the patient's care.

### **Delayed Amputation**

Once the decision to amputate has been made, this should occur as soon as possible. Delays can increase the risk of complications such as wound infection and non-union. Those whose amputation occurred >48hours after initial injury had much higher rates of local wound complication and longer length of stay.<sup>8</sup>

Again, decision-making should involve at least two consultants from different specialties directly involved in the patient's care.

Early pre-operative consultations with prosthetics is beneficial and may assist with long term functional outcomes and psychosocial care.<sup>9</sup>

**Targeted Muscle Reinnervation;**

Targeted Muscle Reinnervation (TMR) is a surgical procedure where the transected motor nerves are sutured to motor nerves of residual muscles, with the expectation they will reinnervate the muscle. Both immediate and delayed amputations should involve a Plastic surgeon as better post-operative phantom limb pain outcomes have been associated with Targeted Muscle Reinnervation (TMR)<sup>19</sup>.

**Transportation of amputated limb**

If an isolated limb salvage is to be considered, thoroughly wash the amputated part in isotonic solution (e.g. Compound Sodium Lactate/Hartmann’s) and wrap it in moist sterile gauze. The limb is then wrapped in a moistened sterile towel, placed in a plastic bag and transported with the patient in a cooling chest with crushed ice. <sup>5</sup> care should be taken not to freeze the limb or allow direct contact with ice.

**Ongoing Care**

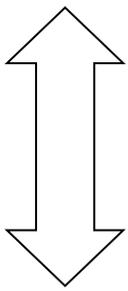
**Early rehabilitation referral;** Inpatient multidisciplinary rehabilitation is effective in improving the physical health and vocational prospects of persons undergoing trauma-related amputations<sup>20</sup>. The rehabilitation physician, through pre-operative and follow-up consultations, can advise on functional expectations, patient and carer education/ supportive counselling, amputation-level and prosthetic considerations, care for the residuum including oedema control, removable rigid dressing (RRD) application for below knee amputations, pre-prosthetic training,

**Pain Management;** Patients in the acute phase of care require early consultation with the acute pain service to assist in managing early and long term pain. Psychological review could be considered.

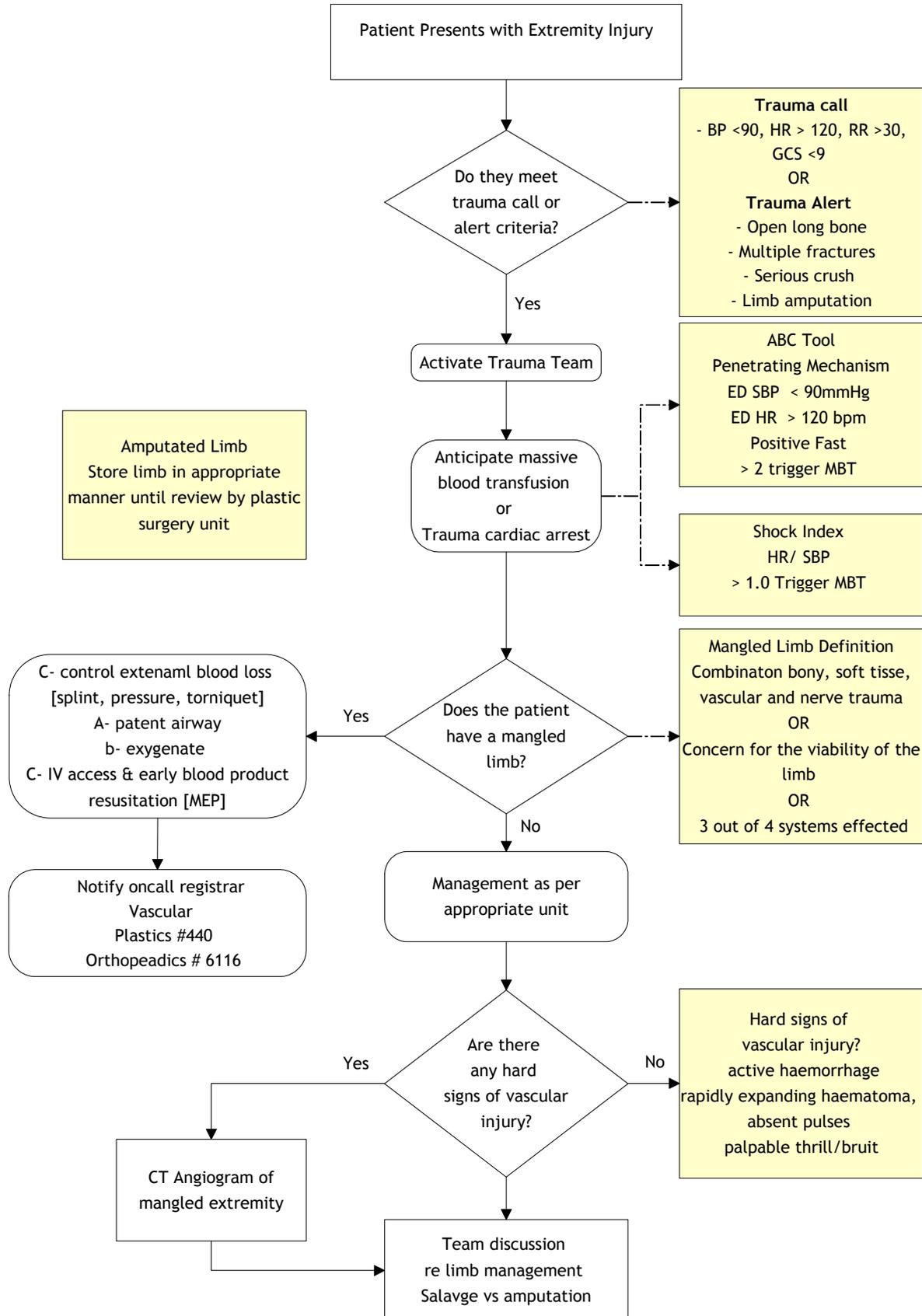
**Table 1: Mangled Extremity Scoring System (MESS)**

Tissue Injury	Characteristics	Details	Points
1	Low Energy	Stab wound, simple closed#, small calibre GSW	1
2	Medium Energy	Open #, dislocation, moderate crush	2
3	High Energy	Shot gun, high velocity bullet	3
4	Massive Crush	Logging, rail road	4
<b>Shock</b>			
1	Normotensive	BP stable	1
2	Hypotensive, transient	BP unstable SBP< 90 mmHg	2
3	Hypotensive	In OR	3
<b>Ischaemia</b>			
1	None	No signs of ischaemia	1
2	Mild	Diminished pulse	2
3	Moderate	Paresthesia, diminished motor	3
4	Advanced	Pulselessness	4
<b>Age</b>			
1	<30 years		1
2	30-50 years		2
3	≥ 50 years		3
<b>Score ≤ 6: salvageable limb, Score ≥ 7 highly predicative of amputation</b>			

**Summary <sup>8</sup>**

Favours Amputation	
	<p>Mangled extremity is immediate threat to life</p> <p>Injury Severity Score (ISS&gt;15), high energy trauma, blunt mechanism, associated head injury, shocked on arrival (BP &lt;90mmhg), &gt; 3L positive fluid balance in first 24hrs</p> <p>Limb attached by only marginal subcutaneous tissue and/or skin</p> <p>Warm ischaemic time &gt; 6 hrs</p> <p>Gross contamination of wound</p> <p>Injury pattern anatomically favourable for reconstruction</p> <p>Hemodynamically stable with only other minor injuries</p> <p>Multidisciplinary team available</p>
Favours Salvage	

**Mangled Lower Limb**



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