Key Clinical Topics in Orthopaedic Trauma

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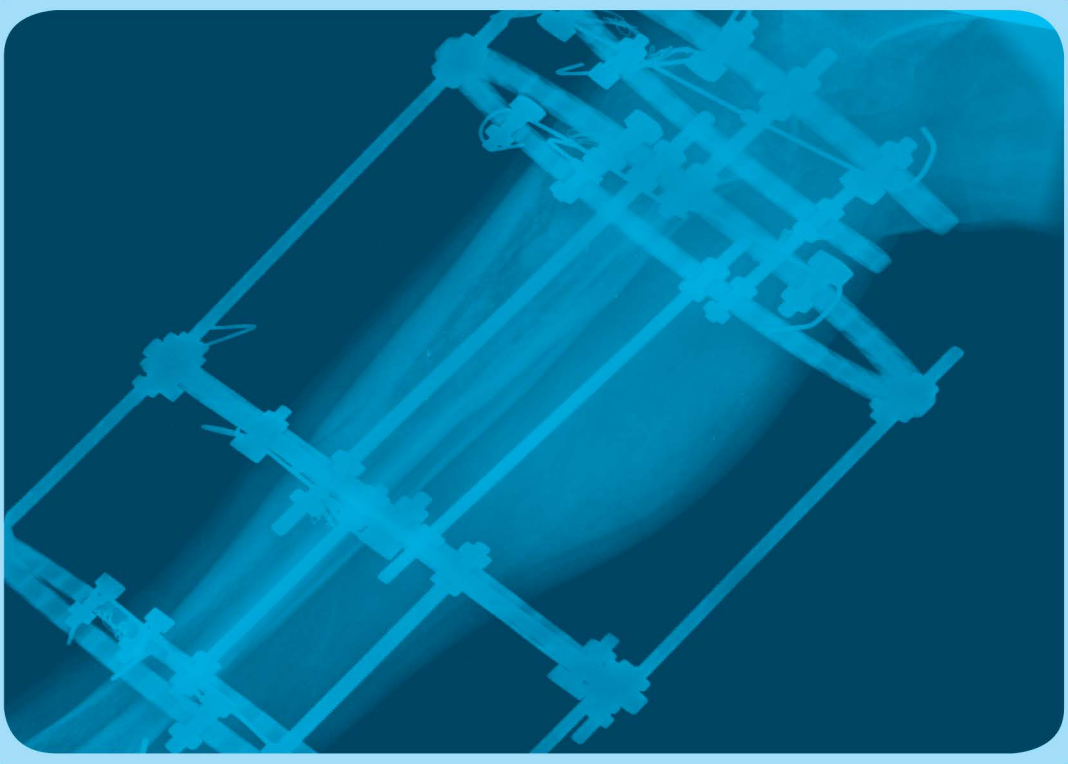

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1 Amputations – mangled extremities and decision making

Key points

- The decision to salvage or amputate a severely injured extremity is one of the most difficult decisions that can face the orthopaedic surgeon
- The decision must be considered in the context of the severity of the injury, other associated injuries, patient's comorbidities and the social, economic and psychological background of the patient
- Multiple scoring systems have been designed to aid the decision process; however, many mangled extremities are borderline cases therefore scores should be used with caution and only as a guide to supplement the surgeon's clinical judgement

Introduction

A mangled extremity is an injury involving many or all components of a limb system, including soft tissue, bone, nerves and vessels. The management of these complex injuries, which is commonly associated with other life-threatening injuries, remains challenging.

The decision whether to salvage or amputate a mangled limb is a matter of debate. Amputation is without a doubt a devastating experience to both patient and surgeon, and with the current advancements in trauma life support and surgical techniques more mangled limbs are technically salvageable. However, the question remains as to whether the final functional outcome with salvage surgery outperforms the function following amputation with the currently available advanced prostheses. A nonfunctional limb that continues to be painful or insensate after prolonged attempts at reconstruction will certainly be inferior to amputation and a good prosthesis. On the other hand, lengthy unsuccessful attempts for reconstruction in a polytraumatised patient is associated with significant morbidity, high costs and even mortality. Furthermore when amputation is inevitable, performing early surgery can improve patient survival, reduce disability and pain, and decrease hospital stay.

Multiple factors affect the outcome in the management of mangled extremities and should be carefully considered when making the decision whether to salvage or amputate. These factors can be classified into:

- Local factors related to the severity of the injury
- Systemic factors like age, smoking and other associated injuries
- Factors related to the psychologic, social, and economic background of the patient like life-style, occupation, wishes and available resources

When considering the aforementioned factors, soft tissue injury was found to have the highest impact on amputation decision, other factors associated with poor outcome are irreparable vascular injury, warm ischaemia for >6 hours, infrapopliteal vascular injury involving all three vessels, loss of protective sensation in nerve injuries, age, smoking, pre-existing co-morbidities and the presence of concurrent injuries. If the need for amputation is not clear in the initial assessment, limb salvage should be attempted.

Mechanism of injury

Road traffic and industrial accidents are the leading causes for mangled upper and lower extremities, with other less common causes including fall from height, high-velocity gunshots, explosions and combat injuries.

Initial management

The management of mangled extremity begins in the emergency department with the standard trauma survey and resuscitation

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in accordance with the Advanced Trauma Life Support protocol. The examination of the extremity then starts with assessment of the degree of soft tissue damage and careful examination of the neurovascular status of the limb. If there is disruption to the arterial flow and reconstruction is considered, intraluminal shunt should be considered. Gross debris should be removed and any significant bleeding controlled by direct pressure. Photographs are useful tool to document the severity of the injury if amputation is considered and to monitor changes if reconstruction is planned. Appropriate dressing should then be used, gross deformities corrected and temporary splinting applied in order to improve pain, minimise further damage and reduce bleeding. Early prophylactic antibiotics and tetanus cover should be initiated and appropriate radiographs can then be planned.

Scoring systems

Different scoring systems have been designed in an attempt to help the decision-making process when dealing with mangled extremity. No single score has been found to be superior to the others and much controversy remains with regard to the ability of these systems to predict successful salvage of the mangled extremities or distinguish cases that are better managed with early amputation. The decision to amputate or salvage should be carefully assessed and should take into account the final functional outcome. A further limitation to scoring systems is that they are applied on the initial assessment of the injury and they do not provide guidance for the decision-making during the course of treatment.

The Mangled Extremity Severity Score (MESS) is the most commonly used and was originally described by Johansen et al. in 1990; a score of 7 or more was predictive of amputation in 100% of cases (**Table 1.1**). However, subsequent studies have been less convincing, reporting low sensitivity for predicting amputation. The limb salvage index (LSI) was proposed by Russell et al. in 1991. The LSI predicts the likelihood of salvage based on detailed intraoperative examination of the injury to six different tissues including artery, nerve, bone,

Table 1.1 Mangled Extremity Severity Score (MESS)

Skeletal/soft tissue injury (points 1–4)		
Low energy	e.g. stab, simple fracture, small calibre gunshot wound	1 point
Medium energy	e.g. open or multiple fractures, dislocation	2 points
High energy	e.g. high speed road traffic accidents	3 points
Very high energy	e.g. high speed trauma with gross contamination	4 points
Limb ischaemia (points 1–3)		
Mild	Pulse reduced or absent, perfusion normal	1 point*
Moderate	Pulse absent, paraesthesia, reduced capillary refill	2 points*
Severe	Pulse absent, cool, paralysed, insensate, no capillary refill	3 points*
Shock (points 0–2)		
Stable normotensive		0 points
Transient hypotension		1 point
Persistent hypotension		2 points
Age (points 0–2)		
<30 years		0 points
30–50 years		1 point
>50 years		2 points
*Score is doubled for ischaemia >6 hours		

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skin, muscle and deep veins. It takes into consideration limb ischaemia time. A score of 6 points or more predicts amputation (**Table 1.2**). Other scoring systems have been proposed like the mangled extremity syndrome index (MESI) developed in 1985 by Gregory et al., the predictive salvage index (PSI) by Howe et al. in 1987 and the NISSSA score (Nerve injury, Ischaemia, Soft-tissue injury, Skeletal injury, Shock, and Age) described by McNamara et al. in 1994.

It is important to note that the above mentioned scoring systems were specifically designed for the lower extremity. The currently available prostheses for the lower extremity support ambulation as the primary function of the lower extremity. However, prostheses for the upper extremity do not restore fine movements, and furthermore these movements are dependent on sensation, therefore a mangled upper extremity has a much larger effect on a patient's life than a mangled lower extremity and the decision-making process for salvage in these cases is quite different from those of the lower extremity. With better functional results following salvage and poorer functional prognosis after amputation, mangled upper extremity should be managed on a case-by-case basis.

Amputation

Amputations should be performed at the lowest possible level to preserve function and reduce metabolic demand. The level

Table 1.2 Limb salvage index (LSI)

Arterial trauma	
• Contusion, intimal tear, partial laceration, palpable pulses	0 points
• Occlusion of two or more shank vessels	1 point
• Complete occlusion of femoral, popliteal or all three shank vessels	2 points
Nerve trauma	
• Contusion or stretch	0 points
• Partial transaction: sciatic, femoral, peroneal or tibial nerve. Complete transaction: femoral, peroneal or tibial nerve	1 point
• Complete transaction: sciatic nerve or both peroneal and tibial nerves	2 points
Bone trauma	
• Closed or open fracture with minimum comminution	0 points
• Closed fracture in at least three sites or open fracture with comminution or open joint with foreign body, or bone loss <3 cm	1 point
• Bone loss >3 cm; type IIIB or IIIC	2 points
Skin trauma	
• Clean laceration, primary repair, 1st degree burn	0 points
• Delayed closure due to contamination requiring skin grafts or flaps or 2nd and 3rd degree burns	1 point
Muscle trauma	
• One muscle or tendon avulsion or laceration	0 points
• Two or more muscles or tendons laceration, or avulsion	1 point
• Crush injury	2 points
Deep vein trauma	
• Contusion, partial laceration	0 points
• Complete laceration, avulsion, or thrombosis	1 point
Warm ischaemia time	
• < 6 hours	0 points
• 6–9 hours	1 point
• 9–12 hours	2 points
• 12–15 hours	3 points
• 15 hours	4 points

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should allow prosthesis to be fitted securely and comfortably. Forequarter amputation (interscapulothoracic) and shoulder disarticulation are very rarely performed; forequarter is only indicated for traumatic avulsion. When shoulder disarticulation is considered, better appearance can be achieved by maintaining the humeral head. A prosthesis can be fitted if 2.5 cm of the proximal humerus is left. Other levels of amputations in the upper limb include transhumeral, transradial, wrist disarticulation and transcarpal. Wrist disarticulation has the advantage of improved pronation and supination and longer lever arm when compared with transradial amputation, however transradial is cosmetically more pleasing and easier for prosthetic application.

In the lower limb the ideal level for transfemoral, above-knee amputation is 12 cm above the knee joint to allow for prosthetic fitting. This level of amputation was found to be superior to through-the-knee amputation as the latter is associated with poorer functional, psychological and cosmetic outcomes. However, the main indication for amputation through the knee is in children, in order to preserve the lower femoral physis.

Transtibial, below-knee amputation, is ideally performed 12–15 cm below the joint. When possible preservation of the knee joint should be attempted as energy demand for below-knee amputation is only 10–30% more, as compared to 40–67% in transfemoral amputation. Excellent prostheses are currently available achieving satisfactory function and near normal gait. Prosthesis can be fitted with shorter stumps up to 5–6 cm.

Other levels of amputation include above-ankle Syme's amputation and partial foot amputations; Chopart amputation through the midtarsal joints; Lisfranc amputation through the tarsometatarsal joints; transmetatarsal amputation; and amputation through the metatarsophalangeal joints.

Further reading

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Ly TV, Travison TG, Castillo RC, et al. Ability of lower-extremity injury severity scores to predict functional outcome after limb salvage. J Bone Joint Surg Am 2008; 90:1738–1743.

MJ Bosse, MacKenzie EJ, Kellam JF, et al. An analysis of outcomes of reconstruction or amputation of leg-threatening injuries. N Engl J Med 2002; 347:1924–1931.

Related topics of interest

- *Topic 2* Amputations – prosthetics and rehabilitation
- *Topic 62* Major trauma – Advanced Trauma Life Support principles
- *Topic 68* Open fractures

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