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Scoring Systems in Major Extremity Traumas

Isil Akgun Demir and Semra Karsidag

Abstract

In the emergency room, every mangled extremity presents with its unique features. Each case requires a different approach and special care, while a surgeon has almost always the same facilities and armamentarium in her/his own setting. Thanks to the advancements in the bone fixation technologies and microsurgical field, the attempts to salvage mangled or even amputated limbs have increased. However, it is still controversial how the decision should be made for salvage or amputation. That is why several scoring systems have been proposed based on retrospective analysis of this group of patients in order to generate a systematic approach and to optimize the outcome. Although they help the surgeon to decide salvation over amputation, or vice versa, the same scores in different patient populations should be interpreted meticulously, and the treatment plan should be established accordingly. The ultimate success is being able to make the most accurate decision possible, and this can be only achieved with experience and extensive knowledge along with sufficient surgical skills.

Keywords: amputation, limb salvage, major trauma, mangled extremity, scoring system

1. Introduction

Approach to major limb traumas is still a challenging subject. The decision-making process is the most critical part directly affecting the outcome. Although several factors such as the general status of the patient, the condition of the limb, and the experience of the surgeon along with the availability of the facilities help greatly determining what to do next, the outcome is mostly unpredictable when it comes to salvaging of an injured or amputated limb.

The decision for salvation should be done only after it is confirmed that the patient has no accompanying life-threatening injuries. Once the patient is stable, then the injured or amputated limb should be examined thoroughly. If the injured part is grossly contaminated, is severely avulsed, or contains vascular injuries at multiple levels, the patient would not benefit from any salvage procedures; moreover, any attempt to salvage the limb might put the patient's life at risk.

The main concerns in this decision-making process focus on the extent of vascular, skeletal, and soft tissue damage, the presence of shock, and warm ischemia time. However, additional criteria such as age, contamination, and patient-related comorbidities cannot be disregarded. The details of the incident are also of great importance such as when it happened, the time interval between the incident and arrival to the hospital and mechanism of injury. Like in every patient presenting with major trauma, the initial evaluation should include the establishment

of a patent airway and optimization of ventilation and blood circulation. After the patient is stabilized, a thorough physical examination should be performed. In patients presenting with mangled extremities, pulsation, skin color and temperature, and capillary return on the distal segment of the involved limb should be checked. If fracture or dislocation of the involved limb is suspected, X-ray or computed tomography images should be obtained. Peripheral nerve examination should be also performed prior to any intervention. Meanwhile, antibiotic therapy should be initiated as soon as possible, especially in case of open fracture, and tetanus prophylaxis must be administered immediately.

2. Scoring systems for upper and lower extremities

In order to be able to evaluate patients with major limb trauma in a more systematic way, several scoring systems have been proposed. The most widely used scoring systems are Mangled Extremity Syndrome Index (MESI); Mangled Extremity Severity Score (MESS); Predictive Salvage Index (PSI); Limb Salvage Index (LSI); Nerve injury, ischemia, soft tissue injury, skeletal injury, shock, age of patient score (NISSSA); and Ganga Hospital Open Injury Severity Scoring (GHOISS) (Tables 1–6).

Mangled Extremity Syndrome Index (Table 1) was described by Gregory et al. in 1985 [2]. The components of this index are injury severity score, bone, age, integument injury, nerve, lag time to operation, pre-existing disease, and shock. A cutoff score of 20 is considered for amputation.

Injury severity score	0–25	1
	25–50	2
	>50	3
Integument injury	Guillotine	1
	Crush/burn	2
	Avulsion/degloving	3
Nerve injury	Contusion	1
	Transection	2
	Avulsion	3
Vascular injury	Arterial transection	1
	Arterial thrombosis	2
	Arterial avulsion	3
	Vein	1
Bone injury	Simple	1
	Segmental	2
	Segmental comminuted	3
	Bone loss <6 cm	4
	Articular	5
Age	<40 years	0
	40–50 years	1
	50–60 years	2
	>60 years	3
Lag time to operation	For each hour over 6 hours	1
Pre-existing disease		1
Shock		2

Table 1.
Mangled Extremity Severity Index (MESI).

Skeletal and soft tissue injury	Low-energy injury	1
	Medium-energy injury	2
	High-energy injury	3
	Very-high-energy injury or above injuries with gross contamination	4
Limb ischemia*	Normal perfusion despite reduced or non-palpable pulse	1
	Slow capillary refill	2
	No capillary refill	3
Shock status	Systolic blood pressure > 90 mm Hg	0
	Transient hypotension	1
	Persistent hypotension	2
Age	<30 years	0
	30–50 years	1
	>50 years	2

*The score is doubled if the warm ischemia time >6 hours.

Table 2.
 Mangled Extremity Severity Score (MESS).

Bone injury	Mild trauma	1
	Moderate trauma	2
	Severe trauma	3
Muscle injury	Mild trauma	1
	Moderate trauma	2
	Severe trauma	3
Arterial injury	Suprapopliteal	1
	Popliteal	2
	Infrapopliteal	3
Delay to the operating room	<6 hours	1
	6–12 hours	2
	>12 hours	3

Table 3.
 Predictive salvage index (PSI).

MESS (**Table 2**) is probably the most commonly used scoring system worldwide for both upper and lower extremity traumas. It was developed by Johansen et al. in 1990 following a retrospective evaluation of patients with lower mangled extremities [3]. The criteria for MESS include age, the presence of shock, warm ischemia time, and skeletal and soft tissue injury. In case the warm ischemia time is longer than 6 hours, the score is doubled. A MESS value equal to or greater than 7 is suggested as highly predictive for amputation.

In 1987 PSI (**Table 3**) was proposed by Howe et al. for scoring lower extremities with orthopedic and vascular injury. In their study, they determined the cutoff value for amputation as 8 [4].

LSI (**Table 4**) was introduced by Russell et al. in 1991 [5]. Unlike the majority of scoring systems, age and the presence of shock are not included in LSI. On the other hand, there are seven evaluation criteria requiring extensive examination which can be only performed intraoperatively. A score of greater than 6 indicates amputation.

Artery	Contusion, intimal tear, partial laceration, or avulsion	0
	Occlusion of ≥ 2 leg vessels, non-palpable pedal pulses	1
	Complete occlusion of femoral or all three leg vessels	2
Nerve	Contusions, stretch injury, minimal clean laceration	0
	Partial transection or avulsion of sciatic nerve; complete/partial transection of femoral and peroneal/tibial nerve	1
	Complete transection/avulsion of sciatic nerve or both peroneal and tibial nerves	2
Bone	Closed fracture in ≤ 2 sites; open fracture without comminution; closed dislocation without fracture; fibula fracture; open joint without foreign body	0
	Closed fracture in at least three sites on same extremity; open fracture with comminution or moderate to large displacement; open joint with foreign body; bone loss < 3 cm	1
	Bone loss > 3 cm; Gustilo type IIIB,C fractures	2
Skin	Clean laceration or small avulsion injuries with primary repair or first-degree burn	0
	Delayed closure due to contamination; wounds requiring skin grafts or flaps; second- and third-degree burns	1
Muscle	Avulsion or laceration of a single compartment or single tendon	0
	Avulsion or laceration ≥ 2 compartments or tendons	1
	Crush injury	2
Deep vein	Contusion, partial laceration, or avulsion; complete laceration or avulsion with intact drainage; superficial vein injury	0
	Complete laceration, avulsion, or thrombosis without adequate venous drainage	1
Warm ischemia time	< 6 hours	0
	6–9 hours	1
	9–12 hours	2
	12–15 hours	3
	> 15 hours	4

Table 4.
Limb salvage index (LSI).

Nerve	Sensate	No major nerve injury	0
	Dorsal	Deep or superficial peroneal nerve injury	1
	Plantar partial	Tibial nerve injury	2
	Plantar complete	Sciatic nerve injury	3
Ischemia*	None	Good to fair pulses, no ischemia	0
	Mild	Reduced pulses, perfusion normal	1
	Moderate	No pulses, prolonged capillary refill, Doppler pulses present	2
	Severe	Pulseless, cool, ischemic, no Doppler pulses	3
Soft tissue	Low	Minimal to no contusion, no contamination	0
	Medium	Moderate injury, low-velocity gunshot wound, moderate contamination, minimal crush	1
	High	Moderate crush, deglove, high-velocity gunshot wound, moderate injury requiring flap, considerable contamination	2
	Severe	Massive crush, farm injury, severe deglove, severe contamination, requires flap	3
Skeletal	Low energy	Spiral fracture, oblique fracture, no or minimal displacement	0

	Medium energy	Transverse fracture, minimal comminution, small caliber gunshot wound	1
	High energy	Moderate displacement or comminution, high-velocity gunshot wound, butterfly fragments	2
	Severe energy	Segmental, severe comminution, bony loss	3
Shock	Normotensive	Blood pressure normal, always >90 mm Hg systolic	0
	Transient hypotension	Transient hypotension in field or emergency center	1
	Persistent hypotension	Persistent hypotension despite fluids	2
Age	Young	<30 years	0
	Middle	30–50 years	1
	Old	>50 years	2

*Score doubles with ischemia >6 hours.

Table 5.
 Nerve injury, ischemia, soft tissue, skeletal injury, shock, age of patient score (NISSSA) [6].

Covering structures: skin and fascia	Wounds without skin loss	Not over the fracture	1
		Exposing the fracture	2
	Wounds with skin loss	Not over the fracture	3
		Over the fracture	4
		Circumferential wound with skin loss	5
Skeletal structures: bone and joints	Transverse/oblique fracture/butterfly fragment <50%		1
		Large butterfly fragment >50% circumference	2
		Comminution/segmental fractures without bone loss	3
		Bone loss <4 cm	4
		Bone loss >4 cm	5
Functional tissues: MT and nerve units	Partial injury to MT unit		1
		Complete but repairable injury to MT units	2
		Irreparable injury to MT units/partial loss of a compartment/complete injury to posterior tibial nerve	3
		Loss of one compartment of MT units	4
		Loss of ≥ 2 compartments/subtotal amputation	5
Comorbid conditions	Drug-dependent diabetes mellitus/cardiorespiratory diseases leading to increased anesthetic risk		2
		Sewage or organic contamination/farmyard injuries	2
		Age > 65 years	2
		Injury-debridement interval > 12 hours	2
		Polytrauma involving the chest or abdomen with injury severity score > 25/fat embolism	2
		Hypotension with systolic blood pressure < 90 mmHg at presentation	2
	Another major injury to the same limb/compartment syndrome	2	

MT, musculotendinous unit.

Table 6.
 The Ganga Hospital Injury Severity Score (GHOISS) [1].

NISSSA score (**Table 5**) was proposed by McNamara et al. in 1994 [6]. It is a modified version of MESS with the addition of nerve injury. The cutoff value of NISSSA for amputation is 11.

The latest scoring system GHOISS was introduced by Rajasekaran et al. in 2006 [1]. The purpose of the authors was to address the paucity of the current scoring systems in tibial injuries without a vascular deficit (Gustilo type IIIB). GHOISS has the maximum number of components when compared with the other scoring systems (**Table 6**). A score of 14 or below is favored for the salvation of the limb, whereas a score of 17 or above indicates amputation. The scores falling between 14 and 17 indicate “the gray zone.”

3. Discussion

The scoring systems were developed to provide a systematic therapeutic approach to mangled extremities.

by grading the severity of an injury. Like every concept that tries to tidy up a complicated clinical scenario, these systems have advantages and disadvantages. Most of the scoring systems address lower extremity injuries, while there is no scoring system specifically designed for upper extremity [7]. A single scoring system cannot be established for both upper and lower extremities since they differ in terms of the amount of muscle bulk and the availability of vascular supply [8]. The warm ischemia time is the single factor that has a direct impact on the extent of tissue necrosis and ischemia-reperfusion injury. Thus, it is included in all scoring systems, as demonstrated in **Table 7**.

The most commonly used systems for upper extremity injuries are MESI and MESS [8, 9]. It has been suggested that MESI scoring is more reliable than MESS in terms of prediction of amputation in mangled upper extremity injuries [8]. However, in order to calculate the MESI score, a thorough examination must be completed, and all the accompanying injuries must be identified, which is time-consuming and precludes practicality. On the other hand, although MESS was criticized by several authors in terms of its accuracy and predictive value, it can be still used preoperatively in many clinical settings with ease [10, 11]. The advantage of MESS is that its calculation relies on inspection and basic examination and is reproducible.

	MESI	MESS	PSI	LSI	NISSSA	GHOISS
Age	✓	✓			✓	✓
Shock	✓	✓			✓	✓
Warm ischemia time	✓	✓	✓	✓	✓	✓
Bone injury	✓		✓	✓		✓
Muscle injury			✓	✓		✓
Skin injury	✓			✓		✓
Nerve injury	✓			✓	✓	
Deep vein injury				✓		
Skeletal/soft tissue		✓			✓	
Contamination					✓	✓
Time to treatment	✓			✓		
Co-morbidity	✓					✓

Table 7.
Comparison of the components of the scoring systems.

The severity of muscle and bone injuries in PSI is graded as mild, moderate, and severe. However, the limits differentiating the severity levels from each other were not described well. Hence it is quite confusing how to grade those injuries with PSI. It would also result in a subjective evaluation rather than a systematic and unbiased calculation [12].

The critic regarding NISSSA is that the severity of nerve injury is only based on the plantar surface sensation indicating the integrity of the tibial nerve, which is no more an absolute contraindication for limb salvage [1]. The sensitivity and specificity of NISSSA have also been found controversial [13].

GHOISS is the first system to describe “gray zone” clearly meaning the scores between 14 and 17. It has been suggested that the outcome of the injuries in the gray zone is dependent on noninjury factors such as the skill and experience of the surgical team, the availability of facilities, and the patient’s request. GHOISS was reported to be useful in children as well [14]. In their series of 107 patients with type IIIB injury, Rajasekaran et al. have reported that the Ganga hospital score showed higher sensitivity and specificity for predicting amputation; however, as they have mentioned in their article, this must be validated with multicenter trials [1].

The absolute contraindications for limb salvage or in other words absolute indications for amputations are still open for discussion. Although there is no established consensus about this topic, the presence of certain factors may favor amputation over salvage. First of all, if the patient has an accompanying life-threatening injury, salvage procedure must not be attempted, and such situations render the scoring systems invalid. Another critical point is the warm ischemia time. Lange et al. have suggested that a crush injury with warm ischemia time longer than 6 hours is an absolute indication for amputation [7]. However, this cannot be applied to upper extremity injuries, since the upper extremity has less muscle bulk than the lower extremity and thus is less prone to develop ischemic injury [8]. Roessler et al. have put emphasis on the fluid balance and absence of a distal pulse on presentation that they are eventual indicators for amputation [12]; nevertheless, current advancements in both medical and surgical fields have overcome those concerns. Another historical indication for limb amputation was the nonfunctional posterior tibial nerve [7]. But, as the LEAP study group has demonstrated, the loss of plantar sensation is no more an indication for amputation [15]. Advanced age may also be included among the indications for primary amputation [16].

Albeit, these systems have been designed to enable the surgical team to make a decision, they are not 100% predictive of the ultimate outcome (salvage vs. amputation), and they are also not predictive of functional recovery among patients with successful extremity reconstruction [17–19]. The sensitivity and specificity rates are quite variable, and all the proposed scoring systems were found to be useful only to some extent [20]. Therefore, in addition to the scores calculated with these systems, patients must be evaluated along with injury pattern and pre-existing comorbidities, and the treatment should be planned also according to the patients’ needs and demands. It is also imperative to take the experience and the skills of the microsurgeon into account. The optimal outcome would be achieved with a systematic multidisciplinary approach, availability of facilities, and always considering what is best for the patient. Raising high expectations both for the surgeon and the patient should be avoided. The technical and individual advancements in the microsurgical field cannot be overlooked; nevertheless, extreme attempts for limb salvage may be harmful to the patient. Moreover, it might become a huge burden for both sides in case it results in a nonfunctional extremity or requires secondary amputation. On the other hand, a patient can still prefer a nonfunctional but salvaged extremity, if there is no contraindication for performing salvage procedure. Therefore, patients’ desire should also be considered as an additional subjective criterion during

decision-making. In a nutshell, there is no single recommended scoring system either for upper or lower extremity injuries. They should be only utilized as guides during the planning of the treatment.

The decision for amputation should never be regarded as a failure. It would also be wise asking for consultation from more experienced colleagues before making the ultimate decision. It is the experience and the quality of clinical judgment that save the patient at the end of the day. The scoring systems are a collateral aid in this hard decision-making process. Their benefits are limited because they rely on retrospective data in small patient populations, and unfortunately it still seems to be unlikely to design a prospective model. What we can do better is to combine our experience, these proposed scoring systems for better interpretation of the scores, and narrowing the gray zone as much as possible. As Russel et al. put into words, “numbers cannot replace clinical judgment” [5].

4. Conclusion

Scoring systems are useful tools in the evaluation of patients with major extremity traumas. However, each patient requires an individual approach and would benefit from the surgeon's own experience.

Conflict of interest

The author declares no conflict of interest.

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