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Case report

Mangled Extremity – Case Report, Literature Review and Borderline Cases Guidelines Proposal

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ABSTRACT

Treatment of a mangled lower extremity represents a major challenge. The decision whether to amputate or attempt reconstruction is currently based upon surgical evaluation. The aim of this paper is to propose a new approach to surgical evaluation based on scoring systems, local clinical status of the patient as well as comorbidities, mechanism of trauma and hospital resources. Available literature regarding this topic was evaluated and a case of patient with mangled extremity is presented. Based on current literature guidelines and evidence-based medicine, management for borderline cases is proposed to aid clinical decision making in these situations. We describe a 44-year old male patient who presented with mangled lower left leg. Despite a borderline Mangled Extremity Severity Score (MESS), due to the overall health status of the patient and local clinical status with preserved plantar sensitivity and satisfactory capillary perfusion, reconstruction was attempted. After 6 months of treatment, all wounds healed completely with no pain, and satisfactory motor and sensory function was achieved. In conclusion, the treatment of mangled extremity treatment should be based on evidence based literature along with a clinical evaluation of every individual patient. Scores are helpful, but should not be taken as the sole indication for amputation.

***Key words**: limb salvage, amputation, lower extremity, leg injuries, decision making, ankle injuries, foot injuries, MESS, mangled lower extremities, VAC*

Introduction

Mangled lower extremity is a consequence of high energy trauma which results in combined bone and soft tissue injury with associated severe bone and soft tissue loss or destruction. Its treatment represents a major challenge and the decision whether to amputate or attempt reconstruction is currently based upon surgical evaluation. Until now, absolute criteria for amputation are considered to be non-reconstructable vascular injury, crush injury with warm ischaemia over 6 hours and severe bone and soft tissue loss with tibial nerve transsection[1,2]. Relative criteria are elderly patients in shock with a mangled limb, massive soft tissue loss associated with bone loss, Mangled Extremity Severity Score (MESS) ≥7 (especially with absent plantar sensation), severe ipsilateral foot trauma, polytrauma and patients that are not expected to tolerate reconstruction[3].

However, these criteria should not be considered as strict rules, but rather as guidelines, due to many patient and wound-related variables[4]. We present the case of a patient with a mangled extremity which matched the criteria for amputation. However, due to an individualized approach to treatment and consideration of many other patient and wound variables, his limb was successfully salvaged with restoration of full function.

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Fig. 1a. Initial injury anterolateral aspect – open ankle fracture with severe soft tissue foot and ankle injury.

Fig. 1b. Initial injury medial aspect – open ankle fracture with severe soft tissue foot and ankle injury.

Case Report

We describe the case of a 44-year old male patient who was run over by a train and presented with an isolated mangled lower left leg 1.5 hours after injury (Figure 1). On clinical presentation in the hospital emergency room, the patient was conscious (Glasgow Coma Scale 15, blood pressure 90/60 mmHg, pulse rate 105/minute), with a respiration rate of 15/minute and oxygen saturation of 99% (measured on the arm using a pulse oximeter). Clinical examination revealed left foot and ankle injury with extensive bone and soft tissue loss. There were no palpable pulses of dorsalis pedis and tibialis posterior arteries with delayed capillary refill. Plantar sensation was present.

A standard X-ray of the left foot and ankle demonstrated fractures of the calcaneus, talus, navicular bone, medial and lateral malleoli with full dislocation in the ankle joint.

After thorough evaluation of all the parameters (Table 1) and concise presentation thereof to the patient, a salvage attempt was decided on according to the protocol (Table 2). Immediate reduction in the emergency room was not possible and the patient was taken directly to the operating room for reduction and stabilization under general anesthesia and X-ray control. Due to massive bone and soft tissue loss, reduction was achieved by bone approximation and stabilization with K-wires and external fixateur (Ex-Fix), along with irrigation and primary debridement of all necrotic and devitalized tissue.

Contrast angiography was subsequently performed which demonstrated disruption of the tibialis posterior artery at the mid-talar level, while the dorsalis pedis artery was visible (Figure 2).

Furthermore, skin was closed with direct sutures on the medial side of the ankle (6x3 cm large wound), while dorsum of the foot (10x6 cm large wound) along with the lateral ankle side (8x3 cm large wound) were left open (Figure 3). Due to severe tissue damage of the patient's foot and ankle region (borderline MESS score) and taking the probability of a high complication rate into consideration, the decision was made to not perform initial early coverage flap reconstruction surgery[5] or vascular shunting[6–8]. Analgesics, tetanus prophylaxis along with antithrombotic prophylaxis were administrated. Regular wound care twice a day with sterile 3% hypertonic saline solution gauze during the first 9 days of the initial de-

TABLE 1
BORDERLINE CASES CRITERIA PROPOSAL FOR MANGLED LOWER LIMB EXTREMITY TREATMENT

Absolute criteria for amputation
Non-reconstructable vascular injury
Crush injury with warm ischemia > 6h
Severe bone and soft tissue loss with tibial nerve transsection
Relative criteria for amputation
Wound-related
Fracture grade and type
Compartment syndrome
Possibility of immediate fixation
Duration and severity of ischemia
Loss of soft tissues of the foot
Patient-related
Associated injuries
Shock
Coagulopathy
Need for vasoconstrictors
Acute Respiratory Distress Syndrome (ARDS)
Age
Comorbidities
Hospital resources
Transport time
Mass / military casualty
Patient cooperation
Scoring systems
Expected outcome
Mandatory weight bearing
Presence of protective sensation
Presence of durable skin and soft tissue

TABLE 2
MANGLED EXTREMITY TREATMENT RECOMMENDATIONS PROTOCOL

Phase 1	
	Massive bleeding stop
	Limb alignment (reduction if possible)
	Sterile covering
	Splintage
	Analgetics
	Antibiotics
	Antithrombotic prophylaxis
	Tetanus prophylaxis
Phase 2	
	Further diagnostics
	– X-ray
	– Doppler
	– CT Angiography
Phase 3	
	Operative treatment with intraoperative decision of:
	– Amputation
	– Reconstruction
	– Stage procedures

marcation period was performed[9] along with the administration of systemic antibiotic treatment according to modern principles[10]. All of the laboratory tests were within normal parameters, including the microbiology findings. There were also no macroscopic signs of ongoing infection.

After the demarcation period had ended, secondary debridement was done together with the plastic surgeon and Negative Pressure Wound Therapy (NPWT) was applied, resulting in gradual soft tissue granulation healing[11–16]. After 3 weeks the progress of healing stopped (Figure 4). Microbiology and laboratory findings were normal with no clinical signs of infection, and a partial

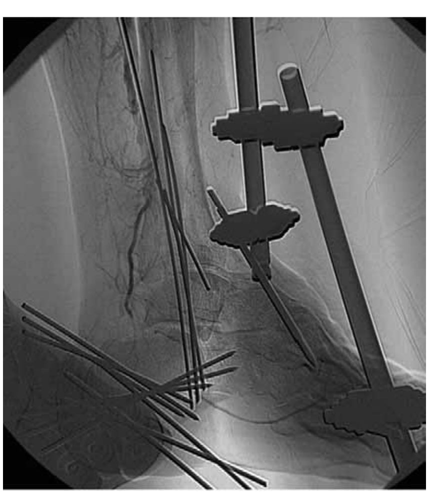

Fig. 2. Contrast angiography K-wire reduction and external fixation.

Fig. 3. Initial management completed.

Fig. 4. 30 days after initial injury – necrosis with no signs of infection.

ostectomy of necrotic calcaneus and cuboid bone parts (later also verified also by histopathology findings) was performed. The wound was dressed with NPWT again. The procedure resulted in significant granulation tissue stimulation and bone healing for an additional 6 weeks (Figure 5a, 5b, 5c) after which the NPWT was substituted due to delayed wound healing with hydrofiber silver dressings[17–19] that successfully continued the process of granulation healing. The Ex-Fix and the K-wires were removed 9 weeks[10] post-implantation following the physiotherapy.

Multi-slice CT angiography with 3D reconstruction was performed 7 months after the initial injury demonstrating the development of collateral vascularization from the fibular artery which supplied the tibialis posterior artery until the middle third of calcaneus whereas the dorsalis pedis artery supplied distal parts of the dorsal plantar arch and digital arteries (Figure 6a, 6b).

After 10 months of treatment, the patient returned to work. All of the wounds had healed completely (Figure 7), with no pain and satisfactory motor and sensory function, allowing the patient to walk with full weight-bearing.

After two years of follow-up, the patient's foot and ankle showed good motor and sensory function enabling painless full weight-bearing (Figure 8). The X-rays presented show full bone healing with good joint congruity (Figure 9).

Fig. 5a. After third debridement – NPWT application.

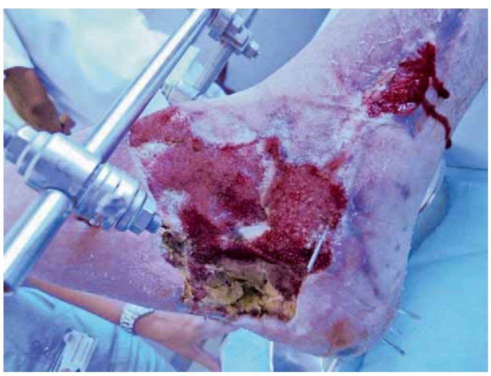

Fig. 5b. After third debridement – wound healing.

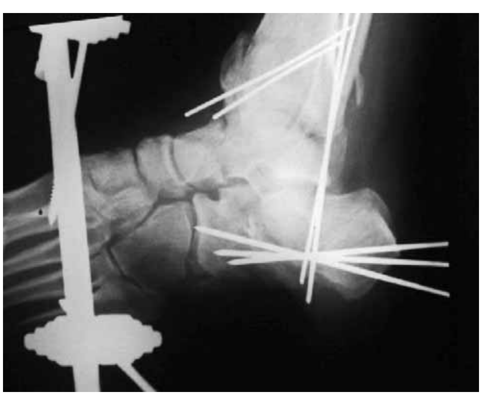

Fig. 5c. After third debridement – RTG after ostectomy.

Discussion

Decision making in a clinical situation of mangled extremity is complex[20]. Due to the development of surgical techniques and technologies, comprehensive reconstructions are possible today in limb salvage procedures[21–26]. However, uncritical limb salvage attempts expose patients to increased morbidity and mortality, prolonged and costly treatment and often result in dysfunctional extremity and disappointment[3].

Although in many cases based solely on clinical examination the decision to amputate or attempt salvage is clear, in borderline cases the decision requires the utilization of different tools, such as scoring systems, that may help differentiate salvageable from non-salvageable extremities.

There is a variety of different scoring systems designed to aid clinical decision-making, such as the MESS, the Limb Salvage Index (LSI), the Predictive Salvage Index (PSI), the Nerve Injury, Ischemia, Soft-Tissue Injury, Skeletal Injury, Shock, and Age (NISSSA) Score, the Hannover Fracture Scale-97 (HFS-97) and many others[3,27–31]. The purpose of these scores is to allow accurate prediction of either the need for amputation or the possibility of salvage. Ideally, a trauma limb-salvage score should have a perfect accuracy with a sensitivity of 100% (all amputated limbs with trauma limb-salvage scores at or above the threshold) and specificity of 100% (all salvaged limbs with scores below the threshold).

Several clinical trials were conducted in order to determine the exact cutoff point for these scores that could

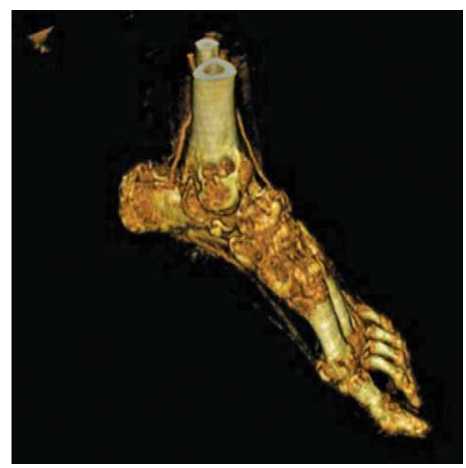

Fig. 6a. Medial aspect of MSCT angiography with 3D reconstruction 7 months after injury.

Fig. 6b. Lateral aspect of MSCT angiography with 3D reconstruction 7 months after injury.

Fig. 7. Limb salvage with complete soft tissue and bone healing 10 months after injury.

be used in decision making. Johansen et al. reported that a MESS score greater or equal to 7 predicted amputation with 100% accuracy[3]. Since delayed amputation in that study resulted in over 20% mortality from sepsis as compared to no mortality in primary amputation[3], the importance of accurate decision making is obviously of paramount importance.

MESS, NISSSA, and HFS-97 scores are greatly influenced by the results of initial neurological examination, with the assumption that an acute sensory debilitation correlates with decreased limb-salvage potential and that the initial examination demonstrates the final deficiency. Still, ischemia, contusion, stretch, or compression can cause transitory neurological deficit. When the LSI is used, the neurological impairment is scored on the basis of anatomical nerve findings. Howe et al. reported a sensitivity of 78% and a specificity of 100% for the PSI. On the other hand, Bosse et al. found the sensitivity and specificity of the PSI for patients with an ischemic limb injury were 56% and 79% when immediate amputations were included in the analysis and 40% and 79% when immediate amputations were excluded. Performance was not improved when only open tibial fractures were considered.

Given the large number of different scoring systems, a prospective, observational, multicenter evaluation of patients with Gustillo IIIB and IIIC open tibia fractures (Lower Extremity Assessment Project – LEAP study) was performed[30]. However, the results of this study failed to validate clinical utility of any scoring system in predicting the need for amputation. On the other hand, it demonstrated the important role of psycho-social issues in long-term outcomes. Furthermore, an initial absence of plantar sensation was not a reliable indicator of the need for amputation as 55% of patients with no plantar sensation initially reported plantar sensation at 24 months. A repeat of the LEAP study confirmed these previous results, emphasizing the inability of scoring systems to accurately predict the need for amputation, although low scores may predict salvage potential[32,33].

Furthermore, there is also not enough evidence in the literature that supports the necessity of urgent temporary vascular shunting followed by orthopedic stabilization in combined orthopedic and vascular foot and ankle injuries with borderline MESS scores[7]. The sequence of procedures and patient care should be adjusted to the specific needs of every patient in order to minimize the rate of amputation. Early soft tissue coverage of a mangled foot and ankle with Vacuum Asisted Closure (VAC) combined with silver hydrofiber dressings is very convenient and results in fewer complications, earlier mobilization and return to work. VAC is also an excellent bridging solution in situations where due to the absence of

Fig. 8a. Foot & Ankle function after two years – Plantar flexion.

Fig. 8b. Foot & Ankle function after two years – Dorsal flexion.

Fig. 8c. Foot & Ankle function after two years – Supination.

Fig. 8d. Foot & Ankle function after two years – Pronation.

Fig. 9a. X-rays after two years – AP view.

Fig. 9b. X-rays after two years – Lateral view.

specialized surgical teams (late at night surgery, local community hospital, etc.) definite treatment[34,35] cannot be immediately performed. Delaying soft-tissue reconstruction beyond 7 days has been associated with increased flap complications and an increased risk of infection[36,37]. Gopal et al. found a deep infection rate of 6% for fractures covered within 72 h, and an infection rate of 29% for fractures covered after 72 hours. The authors concluded that provided an adequate debridement has been performed, immediate internal fixation and healthy soft tissue cover with a muscle flap is safe[38]. However, early aggressive fracture fixation and definitive soft-tissue reconstruction may be favorable for isolated extremity fractures but may not be the safest option for the majority of patients with complex extremity fractures, many of whom have severe additional injuries[39].

Bone and joint infections represent an important problem which consists of three components: the extent of tissue involvement, the microorganism and the host. Management is based on radical debridement, skeletal stabilization, microbial-specific antibiotics, soft tissue coverage, and reconstruction of bone defects. Direct blunt trauma or open wounds of the distal tibia, the ankle joint and the foot often lead to tissue loss and subsequent bacterial colonization. Resistant microorganisms may further complicate the situation, meaning that systemically compromised patients are in a less favorable position[40–42].

Necrotizing fasciitis is a special problem which represents a rapidly progressive infection with necrosis of the fascia and surrounding tissues and has a mortality rate up to 76%[43]. Important clinical findings are pain, hyperpyrexia, chills, cellulitis, edema, warmth, induration, fluctuance, crepitus, skin necrosis and bullae[44]. Immediate aggressive surgical debridement (skin, subcutaneous tissue, muscle debridement, fasciotomy) and administration of high doses of antibiotics are the main steps of treatment.

The reconstruction of the resulting skeletal and soft tissue defects is usually demanding. Contrary to the more proximal parts of the leg, the availability of soft tissue for the coverage of full thickness defects with local or regional flaps in the foot and ankle is limited. However, large defects require complex reconstructive procedures, such as distraction osteogenesis, vascularized bone grafting or transfer of free flaps[45,46]. Finally, amputations and more extensive amputative procedures in cases of diffuse osteomyelitis can fail as a limb and life saving procedure in resistless patients. In selecting the appropriate management plan, the surgeon should rely on the detailed evaluation of the patient, the extent of the bone and soft tissue involvement and the type and susceptibility of bacterial pathogens[47].

The importance of general and local conditions should be particularly evaluated in polytrauma for which there is still no clear guideline on whether to amputate or not[48]. In sepsis and/ or MOF occurrence, with the presence of a MESS score >7, the incidence of tibio-peroneal trunk injury and the occurrence of postoperative deep wound infection are significant independent factors for limb loss[49].

In the end, functional demands and expectations of the patients, in combination with the estimated time required for the reconstructive procedures, are also critical parameters for the final decision. Primary amputation should not be considered as a treatment failure, but rather as a means of meeting the goal of treatment[50]. As Hansen pointed out, we should not let the heroism triumph over reason[51].

Conclusions

The results of treatment of the presented case reflect the findings of the LEAP study, clearly demonstrating the possibility of limb salvage even in patients with borderline MESS scores, thus showing that one can not rely on definite cutoff points when using scoring systems.

Fig. 9c,d. X-rays after two years – Foot views.

It is therefore necessary to include other patient and wound variables in addition to scoring systems in order to allow improved treatment outcomes using an individualized approach to patients with mangled extremities.

Consequently, there is an obvious need for comprehensive criteria proposal of mangled extremity treatment for borderline cases (Table 1) that will take into account not only scoring systems, but also important patient and wound characteristics[52].

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OŠTEĆENI EKSTREMITET – PRIKAZ BOLESNIKA, PREGLED LITERATURE I PRIJEDLOG SMJERNICA LIJEČENJA ZA GRANIČNE SLUČAJEVE

S A Ž E T A K

Liječenje oštećenih donjih ekstremiteta predstavlja veliki izazov. Odluka da li amputirati ili pokušati rekonstrukciju se trenutno temelji na kirurškoj procjeni. Cilj ovog clanka je predloziti novi pristup kirurške evaluacije, koji bi se bazirao na sistemima skoriranja, lokalnom kliničkom statusu pacijenta, a uzimajući u obzir pacijentovo stanje, komorbiditete, sam mehanizam traume, te mogućnosti ustanove u kojoj se ozlijeđenik liječi. Dostupna literatura vezana uz ovu temu je evaluirana i prikaz slučaja pacijenta s oštećenim ekstremitetom je prezentiran. Temeljem trenutnih smjernica iz literature te medicine temeljene na dokazima, postupak liječenja graničnih slučajeva je predložen u svrhu pomoći donošenja kliničke odluke u ovim situacijama. Opisujemo 44-godišnjeg pacijenta sa oštećenjem potkoljenice i stopala. Usprkos graničnom Mangled Extremity Severity Score (MESS), zahvaljujući dobrom općem zdravstvenom stanju pacijenta i lokalnom kliničkom statusu sa očuvanim plantarnim senzibilitetom i zadvoljajućom kapilarnom perfuzijom, pokušaj rekonstrukcije je napravljen. Nakon 6 mjeseci liječenja, sve su rane kompletno zacijelile, a sam ekstremitet je bezbolan sa zadovoljavajućom motornom i senzornom funkcijom. Kao zaključak, liječenje oštećenih ekstremiteta bi se pored zasebne kliničke procjene svakog pacijenta trebalo bazirati na literaturi temeljenoj na dokazima. Sistemi skoriranja su od pomoći, ali ih ne bi trebalo uzimati kao apsolutnu indikaciju za amputaciju.