

## Mangled Extremity Severity Score in Children

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**Summary:** Treatment of the severely traumatized or mangled lower extremity poses significant challenges. The Mangled Extremity Severity Score (MESS) is a scale that uses objective criteria to assist with acute management decisions. Most research on the MESS has been in adults or combined series with few children. The study was performed to investigate the MESS in children exclusively. The MESS was applied retrospectively to 36 patients with grades IIIB and IIIC open lower extremity fractures collected from two level 1 pediatric trauma centers. Patients were divided into limb salvage and primary

amputation groups based on the decision of the treating surgeon. In the salvage group there were 18 grade IIIB fractures and 10 grade IIIC fractures. The MESS prediction was accurate in 93% of the injured limbs. In the amputation group eight limbs met the inclusion criteria; the MESS agreed with the treating surgeon in 63% of cases. These findings suggest the MESS should be considered when managing a child with severe lower extremity trauma. **Key Words:** Amputation—Grade III open fractures—Limb salvage.

Treatment options for the severely traumatized or mangled lower extremity are some of the most challenging decisions facing the orthopaedic surgeon. Each injury has unique characteristics, and such injuries occur infrequently in children. Damage to multiple organ systems (skin, bone, vessel, and nerve) requires a multidisciplinary approach to the patient, and limb salvage may require numerous surgical procedures. Extensive damage to some limbs makes salvage impossible. Other limbs are technically possible to reconstruct, but the resulting extremity is dysfunctional and the patient ultimately requires an amputation. Identification of this latter group early in the course of management avoids substantial investment of resources, time, and emotion in a limb doomed to failure.

Scales such as the Mangled Extremity Severity Score (MESS) (15), Mangled Extremity Syndrome Index (10), Limb Salvage Index (21), and Predictive Salvage Index (14) were designed to help surgeons determine whether an injured limb would be optimally treated by salvage or early amputation. The MESS, the most recognized scale in the orthopaedic literature, uses objective criteria at presentation to determine whether an injured limb should be saved. Points are assigned for the skeletal and

soft tissue injury, vascular status, blood pressure, and age of the patient, with the resulting score predicting amputation or salvage. The MESS was initially validated both retrospectively and prospectively, but the authors did not report the number of children in the series (13,15).

Most of the subsequent research on the MESS has used adults. Several reviews of open fractures in children, however, have shown superior outcomes when compared with adults (1,2,7,11,16,22). We evaluated the applicability of the MESS to children exclusively.

### METHODS

The hospital records of all children from two pediatric trauma centers who presented with open lower extremity long bone fractures between 1985 and 1995 were reviewed. Included patients had grade IIIB or IIIC open fractures as classified by Gustilo et al. (12) or traumatic amputations. Amputations below the level of the ankle were excluded. All patients were skeletally immature, and patients who had attempted limb salvage had minimum follow-up of 1 year.

Eligible patients were divided into limb salvage and primary amputation groups, determined by the decision of the treating surgeon the day of admission. The age, mechanism of injury, MESS, Pediatric Trauma Score (PTS) (23), number of surgical procedures, length of hospital stay, and final outcome were recorded. The final outcome, amputation or salvage, was compared with the MESS prediction.

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## RESULTS

Forty-three limb salvage and nine primary amputation patients met the inclusion criteria. No record documented use of the MESS.

### Limb salvage

In the limb salvage group, nine records lacked documentation to generate an unequivocal MESS, six patients lacked documentation of skeletal immaturity, and one patient had less than 1 year of follow-up. Thus, 27 children with 28 injured limbs made up the cohort. Patients from each institution were comparable in number, age, and sex distribution.

Twenty-two boys and five girls made up the salvage group. The average age was 9.5 years (range 2–15), with a mean follow-up of 6.3 years (range 1–12). The mechanisms of injury are displayed in Table 1. There were nine grade IIIB femur fractures, two grade IIIC femur fractures, nine grade IIIB open tibia fractures, and eight grade IIIC tibia fractures. Associated fractures in addition to the mangled limbs are listed in Table 2. Two patients sustained closed head injuries. The average PTS was 5.6 (range 2–8). Mean hospital stay was 30 days, with an average of 4.8 procedures (range 2–8) per limb.

In all 28 limbs, the MESS predicted salvage. Twenty-six were salvaged successfully, representing 93% accuracy. The failures were in two children with grade IIIC tibia fractures. One 6-year-old girl had her leg crushed in a winch. She had application of an external fixator and vascular reconstruction, but revascularization ultimately failed and a below-knee amputation was performed at the third procedure on hospital day 4. The other child was a 6-year-old boy who had a partial amputation by a boat propeller. He underwent revascularization, stabilization, and early flap coverage. He developed an infection after surgery, and despite multiple debridements salvage failed. He had a below-knee amputation on hospital day 18.

### Primary amputation

Nine children with 12 injured limbs underwent primary amputations. The mean age was 9.6 years (range 4–14) and the mean PTS was 5.1 (range 4–6). The mechanisms of injury are listed in Table 3. One child died.

An accurate MESS could be calculated for eight of the limbs in the amputation group. The MESS predicted amputation in five limbs, representing 63% agreement with the treating surgeon. The MESS predicted salvage in a 12-year-old girl who sustained a grade IIIC tibia fracture in an automobile accident. The surgeon amputated the limb acutely because the tibial nerve was transected. A

**TABLE 1.** Mechanism of injury in 27 salvage patients

Mechanism of injury	Patients (n)
Pedestrian vs. MVA	12
Motorcycle vs. MVA	4
Machinery	3
MVA	2
Other	6

MVA, motor vehicle accident.

**TABLE 2.** Associated fractures in 27 salvage patients

Location	Fractures (n)
Femur	6 (3 open)
Tibia	3 (1 open)
Metatarsal	4
Face	3
Pelvis	2
Humerus	2
Other	4

10-year-old boy sustained bilateral grade IIIC tibia fractures and other life-threatening injuries in a motor vehicle accident. The MESS predicted salvage for both limbs, but acute amputations were performed because it was determined the patient could not survive bilateral reconstructive efforts.

## DISCUSSION

Management of the mangled lower extremity poses difficult challenges for the surgeon. Salvage of the limb is a desirable goal, but reconstruction may not result in a functional extremity. Caudle and Stern (6) reported dismal outcomes in adults with grade III open tibia fractures, with high rates of early and late amputation. Similar experience of other authors supports the opinion that limb salvage cannot be the only goal of treatment (8,9). Identification of limbs best treated by early amputation remains the challenge.

Late amputation is devastating to the patient because of the time, resources, and emotional investment in the limb. Caudle and Stern (6) reported amputations up to 5 years after injury. All amputations in our study were performed during the initial hospital stay. We cannot determine whether reconstructive efforts in children yield outcomes that obviate late amputation. The sample size may have failed to capture children requiring late amputation, or inadequate follow-up may have excluded late failures.

Advances in bone and soft tissue reconstruction have improved outcomes and complicated the decision-making process for severe limb trauma. Lin et al. (17) prospectively increased the MESS threshold for acute amputation from 3 points to 10 and reported a successful salvage rate of 75% with a minimum of 2 years of follow-up. After developing unique, strict criteria for limb salvage attempts, Quirke et al. (19) successfully reconstructed 13 of 14 limbs with vascular injuries. Adults made up the majority of patients in both series. The applicability to children is unclear, although the data are encouraging.

**TABLE 3.** Mechanism of injury in 9 amputation patients

Mechanism of injury	Patients (n)
Train	2
MVA	2
Pedestrian vs. MVA	2
Lawn mower	1
Farm equipment	1
Train vs. MVA	1

MVA, motor vehicle accident.

The risks of indiscriminate attempts at limb salvage have been well documented. Bondurant et al. (4) reported significantly higher rates of sepsis, death, surgical procedures, and cost in patients who had delayed amputation. Georgiadis et al. (9) found that patients with salvaged limbs took longer to bear full weight, were less likely to work, and were more likely to consider themselves disabled than patients who had acute amputations. Adults represented the majority of patients in both series.

Few data on pediatric mangled extremities exist, and to our knowledge there is no series specifically addressing this problem. Several authors have studied open pediatric fractures. Younger children have superior outcomes compared with adults, with lower rates of delayed union, nonunion, and osteomyelitis (1,2,7,11,16,22). Buckley et al. (5) reported complication rates comparable to adults but found the complications easier to treat in children.

The superior outcomes in children with open fractures suggest potentially different results with the MESS. Age is a variable in the MESS calculation, but all patients younger than 30 receive a score of 0 in the age category. Therefore, the MESS functionally has only three variables in children. The MESS would miss such differences in children if present. Open fracture studies have shown that the transition between pediatric and adult fracture behavior occurs in the early teen years (2,11,22). The small size of our series prevented a more comprehensive analysis of the age variable.

Robertson (20) reviewed the MESS in 164 mangled adult extremities and found the MESS to be highly predictive of acute amputation but less predictive of successful salvage. Other authors have questioned the predictive value of the MESS and other decision-aiding scales (3,18). We found that the MESS accurately predicted successful salvage in 93% of patients and agreed with amputation in 63%.

The study has weaknesses. Although no chart documented use of the MESS, we cannot exclude the possibility that the score was used by surgeons in the decision-making process. The amputation data have limitations because no attempt was made to salvage limbs that possibly could have survived. A larger series would perhaps identify more failures. In addition, the study design omits additional procedures or late amputations performed at outside institutions or in adulthood.

Like Robertson (20), we found the assignment of points for the skeletal and soft tissue category problematic in some instances. Four points are assigned for massive crush injuries such as industrial accidents. The limb of a child struck by a rapidly moving vehicle may absorb comparable energy, although the MESS allows assignment of only two points in this situation. The treating surgeon could overcome this limitation by using his or her discretion when assigning points in this category.

Ideally, a decision-aiding scale would correlate with functional outcomes. The MESS, however, uses only amputation and successful salvage as outcomes. Functional evaluation of children after severe limb trauma

would provide more meaningful data for comparison with acute predictions.

Surgeons must evaluate each patient with a severely traumatized limb individually. The decision to attempt reconstruction balances several factors including associated injuries, injury complexity, and surgical expertise. Undoubtedly, life always takes precedence over limb, but beyond this principle the surgeon must weigh the other variables to make a decision. Our limited data cannot justify universal application, but our preliminary results suggest that the MESS should be considered when managing a child with severe lower extremity trauma. Long-term functional evaluation will provide important supplementary information.

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