

# Evaluation of the Mangled Extremity Severity Score in Combat-Related Type III Open Tibia Fracture

Andrew J. Sheean, MD,\* Chad A. Krueger, MD,\* Matthew A. Napierala, MD,\*  
Daniel J. Stinner, MD,\* and Joseph R. Hsu, MD,† on behalf of the Skeletal  
Trauma and Research Consortium (STReC)

**Objectives:** The purpose of this study was to determine the extent to which the Mangled Extremity Severity Score (MESS) predicted outcomes for soldiers sustaining combat-related Gustilo–Anderson type III open tibia fractures.

**Design:** Retrospective cohort study.

**Setting:** Tertiary trauma center.

**Patients:** Service Members with combat-related type III open tibia fractures occurring between 2003 and 2007 treated definitively in a US military medical center.

**Intervention:** Amputation or limb salvage.

**Main Outcome Measurements:** MESS, amputation or limb salvage.

**Results:** Complete data were available for 155 patients treated for type III open tibia fractures. One hundred ten patients had salvaged limbs, and 45 patients had lower extremity amputations. The mean MESS values for amputees and patients treated with limb salvage were 5.8 and 5.3 ( $P = 0.057$ ), respectively. The sensitivity and specificity of a MESS  $\geq 7$  predicting amputation was 35% and 87.8%, respectively. A MESS value of  $\geq 7$  was found to have a positive predictive value on 50%. Thirty-three percent of patients treated with amputation had an associated vascular injury versus 12.7% of patients treated with limb salvage ( $P < 0.0026$ ).

**Conclusions:** There was no significant difference between MESS values of amputees and those treated with limb salvage. Moreover,

these data demonstrate that the MESS is neither sensitive nor accurate in predicting amputation.

**Key Words:** MESS, type III open tibia, outcomes

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## INTRODUCTION

The preponderance of extremity trauma sustained during Operation Iraqi Freedom and Operation Enduring Freedom is well documented with as much as 54% combat wounds involving the extremities.<sup>1</sup> It has been demonstrated that the majority of these injuries (79%) are secondary to explosions and frequently involve open fractures.<sup>2–4</sup> These high-energy mechanisms often involve significant soft tissue and neurovascular injuries, in addition to the bony injuries, to an extent that early amputation may be the best option for the patient. Multiple scoring systems have been proposed to aid in the decision of whether to amputate or salvage injured limbs, however, these methods have not been consistently validated in the literature among either civilian and military trauma patients.<sup>5–8</sup> Perhaps, the most widely used score to aid in this decision-making process is the Mangled Extremity Severity Score (MESS). In military populations, controversy was amplified by conflicting publications using limited numbers of patients.<sup>6,8</sup> Consequently, a more comprehensive analysis of the MESS in wartime injuries is warranted. The purpose of this study was to assess the predictive value of the MESS among a large population of the US military patients sustaining combat-related type III open tibia fractures and to ultimately provide a more definitive answer as to whether or not there seems to be a clinical value in using the MESS to determine limb viability.

## METHODS

After institutional review board approval of the study protocol, service members with combat-related type III open tibia fractures occurring between 2003 and 2007 treated definitively in a US military medical center were identified. Patient records were reviewed to characterize the injuries and outcomes, including limb salvage versus amputation, age, gender, mechanism of injury, injury pattern, associated injuries, and presence of complications. Patients' theater records were then queried from the Patient Administration Systems and Biostatistics Activity (PASBA) using Web

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From the \*Department of Orthopaedic Surgery, Brooke Army Medical Center, San Antonio Military Medical Center, Fort Sam Houston, TX; and †Department of Orthopaedic Surgery, Carolinas Medical Center, Charlotte, NC.

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This study commenced after being approved by the United States Army Institute of Surgical Research Institutional Review Board.

Reprints: Andrew J. Sheean, MD, Department of Orthopaedic Surgery, Brooke Army Medical Center, San Antonio Military Medical Center, 3851 Roger Brooke Drive, Fort Sam Houston, TX 78234 (e-mail: Andrew.j.sheean.mil@mail.mil).

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## Report Documentation Page

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Interface Scanned Patient Records (WISPR). The specific information obtained from these records was the Gustilo–Anderson open fracture classification, patient’s age, systolic blood pressure, injured extremity vascular status, and extremity soft tissue injury. The last 4 variables were assigned values and summed as described in previous studies to calculate the MESS.<sup>5</sup> To determine the ability of the MESS to predict amputation, both sensitivity and specificity were calculated, where sensitivity was defined as the number of limbs amputated with scores at or above the threshold divided by the total number of limbs amputated. The specificity was defined as the number of salvaged limbs with scores below the threshold divided by the total number of salvaged limbs. Additionally, predictive values were calculated where the positive predictive value was defined as the number of limbs amputated with scores at or above the threshold divided by the total number of limbs with scores at or above the threshold. The negative predictive value was defined as the number of salvaged limbs with scores below the threshold divided by the total number of limbs with scores at or below the threshold. A MESS of  $\geq 7$  was used as the threshold because this score has been previously reported as being a reliable predictor for amputation.<sup>5,8,9</sup> The MESS for each group (limb salvage vs. amputation) was compared using the Wilcoxon/Kruskal–Wallis Tests. A 2-tailed Fisher exact test was also used to compare the categorical data. Statistical significance was set at  $P \leq 0.05$ . The standard error of the mean (SEM) was calculated for each value.

**RESULTS**

Complete data were available for 153 patients who sustained type III open tibia fractures of 155 lower extremities. Thirty-nine patients (40 extremities) required amputation, whereas 114 patients (115 extremities) were treated with limb salvage (Tables 1 and 2). One patient required bilateral amputations, and 1 patient had 1 extremity reconstructed while the other was amputated. The median age of all patients was 23 years (range, 19–34 years), the median ages of patients treated with amputation or limb salvage being 24 and 25 years, respectively (Table 1). Eighty-four percent of extremities were injured in a blast and 100% of extremities injured by gunshot wound (GSW) were salvaged (Table 3).

The median MESS for amputated extremities was 6 (mean, 5.8; SEM, 0.28) while salvaged extremities had a median MESS of 5 (mean, 5.3; SEM, 0.11). There was

**TABLE 1.** Demographics and Gustilo–Anderson Classification Distribution

	Total	Median Patient Age, yrs	IIIA (%)	IIIB (%)	IIIC (%)
Total extremities	155	23	60 (39)	70 (45)	25 (16)
Amputated extremities	40	24	9 (23)	19 (48)	12 (30)
Salvaged extremities	115	25	51 (44)	51 (44)	13 (11)

**TABLE 2.** Distribution of MESS Values

	Total
Extremities	155
Amputated extremities	40
MESS $\geq 7$	14
MESS $< 7$	26
Salvaged extremities	115
MESS $\geq 7$	14
MESS $< 7$	101

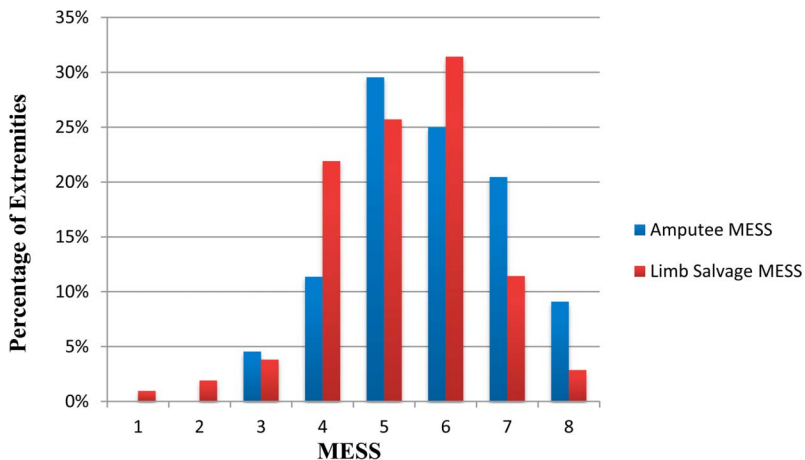
no significant difference between the MESS of the amputated extremities and the salvaged extremities ( $P = 0.057$ ). Thirty percent of patients who required amputation had associated vascular injuries compared with 11% of those treated with limb salvage (Table 1,  $P < 0.0026$ , 95% confidence interval; 0.07–0.34). Figure 1 depicts the distribution of MESS values among those treated with amputation or limb salvage. Among amputated extremities, 57.5% had a MESS of 6–8. Among those extremities that were salvaged, 43.5% had a MESS of 6–8. The sensitivity, specificity, positive predictive value, and negative predictive values of a MESS  $\geq 7$  were 35%, 87.8%, 50%, and 79.5%, respectively (Table 4). There were no significant differences between MESS and either the presence of nerve injury ( $P < 0.15$ ) or blast injury ( $P < 0.47$ ) between amputated and salvaged limbs. Six limbs initially salvaged went on to require amputation at an average of 15 months (range, 13.3–19.6 months) after their index injuries. Of these 7 extremities, 5 had a MESS of 5, and 2 had a MESS of 6 (Table 5). An associated nerve injury was present in the 57% who underwent late amputation versus 30% of extremities that were salvaged ( $P < 0.0664$ ).

**DISCUSSION**

Scoring systems to assist the surgeon in determining the viability of a severely injured extremity were created to replace subjective clinical assessments with objective clinical criteria. For such scoring systems, high specificity would ensure that a minimum number of salvageable extremities would be graded above the proposed threshold for amputation and high sensitivity would imply that an unsalvageable mangled extremity would be amputated expeditiously so as to avoid the potential morbidity associated with a delayed procedure. Johansen et al developed the MESS through a retrospective analysis of 25 patients with combined vascular and orthopaedic injuries and suggested that a MESS of  $> 7$  be used to compel amputation. This threshold was subsequently

**TABLE 3.** Distribution of Injuries by Mechanism

	Total (%)	Salvaged Extremities (%)	Amputated Extremities (%)
Blast	130 (84)	95 (73)	35 (27)
GSW	13 (8)	13 (100)	0 (0)
MVC	8 (5)	4 (50)	4 (50)
Other	5 (3)	4 (80)	1 (20)



**FIGURE 1.** MESS values by frequency. **Editor’s note:** A color image accompanies the online version of this article.

validated by the same authors using a prospective review of 25 additional injured extremities as a MESS of  $\geq 7$  was 100% predictive of an amputation.<sup>5</sup> Rush et al performed a similar retrospective analysis of 60 combat-related lower extremity injuries and stated that a MESS  $>7$  was a useful threshold for predicting amputation among service members. While these authors found the MESS of salvaged and amputated extremities to be 2.44 and 7.87 respectively, their analysis was limited by a relatively small sample size and a small number of extremities with MESS values in a range of 5–8, where a predictive tool is likely to be of the greatest utility. In the current cohort, there was not a statistically significant difference between the MESS of amputated and salvaged extremities (6 vs. 5,  $P = 0.057$ ), suggesting that the MESS should not be used in solitude to determine if a severely injured extremity should be amputated or salvaged.

The LEAP study prospectively evaluated the predictive accuracy of several scoring systems (MESS, Limb Salvage Index, Predictive Salvage Index, Nerve Injury, Ischemia, Soft Tissue Injury, Shock, and Age of Patient Score) and showed high specificities but considerably lower sensitivities than previously reported.<sup>7</sup> Additionally, Ly et al showed that these scoring systems were unlikely to accurately predict the functional recovery of those patients undergoing limb salvage.<sup>10</sup> More recently, Brown et al evaluated the predictive accuracy of the MESS among a larger cohort (86 limbs) with ballistic lower extremity injuries sustained in Iraq and Afghanistan. The authors found the MESS to have a positive predictive value of 64.3% and a sensitivity and specificity of 85.7% and

84.4% respectively. Based upon these results, the authors concluded that the MESS was not predictive of amputation in the setting of combat-related extremity trauma. The sensitivity and specificity of the MESS among the present cohort population (35% and 87.8%, respectively) were worse than those previously described by Bosse et al (46% and 91%, respectively) and markedly worse than the sensitivity shown Brown et al (85.7% and 84.4%).<sup>6,7</sup>

To our knowledge, this data on type III open tibia fractures represents the largest study assessing the MESS in predicting the need amputation among combat-related lower extremity injuries. A larger sample size decreases the likelihood of a type I error and helps to clarify whether or not the MESS is of any real clinical utility. Moreover, this study’s population—military members aged 19–34 years whose overall health status allowed for active duty service—is relatively homogenous and presumably devoid of medical confounders. The presence of a vascular injury and prolonged hypotension has been shown to be predictive of amputation among combat-related extremity injuries.<sup>6</sup> This series demonstrated a similar finding that those extremities with a vascular injury were significantly more likely to go on to an amputation than those without a vascular injury. There were 14 limbs with a MESS  $>7$  that were treated successfully with limb salvage, which yielded a positive predictive value of 50%. Had a MESS of 7 been used for amputation, 1 out of every 2 limbs

**TABLE 4.** Analysis of Results

MESS 7 or Greater	Amputation Required		Predictive Value (%)
	Yes	No	
Positive	True positive = 14	False positive = 14	50
Negative	False negative = 26	True negative = 101	79.5
	Sensitivity = 35%	Specificity = 87.8%	

**TABLE 5.** Unsuccessfully Salvaged Limbs

MESS	Mechanism	Time to Amputation, mo	Fracture Type	Associated Nerve Injury
5	Blast	13	C	Yes
5	GSW	13	B	Yes
5	Blast	17	B	Yes
5	Blast	15	B	No
5	Blast	12	B	Yes
6	Blast	18	A	No
6	Blast	19	C	No

with a value  $>7$  that were successfully salvaged would have been amputated. Such an amputation would be particularly disappointing in the setting of some of the promising prosthetic and rehabilitation options that are being developed currently for limb salvage patients.<sup>11</sup> Similar to findings of Brown et al, the MESS was not clinically helpful in determining the optimal approach in those with a MESS of 5–8.

The weaknesses of this study are typical of retrospective analyses as the strength of the data is contingent upon the quality of the medical records at the time of injury as well as throughout subsequent follow up care. Moreover, the generalizability to the general population may be limited secondary to the prevalence of blast injuries and the relatively young age of patients in this cohort. These patients likely have multiple injuries to many organ systems and were likely to have other conditions of their injury and their treatment that may not be transferable to a civilian population. It should be noted, however, that there was no statistical difference between the outcomes of those patients who were injured in blasts versus other combat-related mechanisms. This fact may very well reflect advances in pre-hospital care as well as improvements in the theater aeromedical evacuation system and surgeon experience over a decade of armed conflict in treating casualties of explosions.

Overall, these results confirm that in the setting of high energy, combat-related lower extremity trauma, the MESS is ineffective in predicting the need for amputation at the point of injury. The differences in MESS found between those limbs that were amputated and salvaged are significant but unlikely to be able to assist in accurately determining what treatment option is best for the severely injured lower extremity. In addition, it appears that strict application of

the MESS may actually put limbs that could be successfully salvaged at risk for unnecessary amputation. As such, the authors recommend against using the MESS to determine the treatment of severe, combat-related lower extremity injuries.

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## Invited Commentary

Multiple composite scoring systems have been developed in an attempt to assist rapid and safe decision making for patients with a traumatic limb at risk. The validity and reliability of these scoring systems has been questioned in both the civilian and military trauma population over the last 10 years.<sup>1,2</sup>

Sheehan et al have retrospectively examined the Mangled Extremity Severity Score (MESS) in 155 patients with type III open tibia fractures caused by combat injuries and found a low sensitivity (31%) and high specificity (87%) of a MESS  $\geq 7$  for predicting amputation.<sup>3</sup>

The MESS score was devised almost 25 years ago, and there have been significant improvements in trauma care and education in that time.<sup>4</sup> These improvements are demonstrated by higher MESS scores reported in the current limb salvage population compared with the initial report (5.3 vs. 4).<sup>3,4</sup>

Composite scoring systems suffer the inherent problems of what data to include in the score and how to weight

individual data within the final composite score. Further optimal application of the score depends on the pretest probability of an outcome, thereby altering the predictive values of the score.

The importance of vascular injury in traumatic amputation should not be understated. In the initial report of the MESS by Johnson et al, all 26 limbs had an arterial injury requiring revascularization, therefore all the included tibia fractures were type III C. Brown et al<sup>2</sup> demonstrated the importance of vascular injury in combat-related amputation, with vascular injury in the unstable patient being the main factor to predict amputation. Sheehan et al has further highlighted this important point with 48% of all amputated limbs having a vascular injury. Unfortunately in the main finding of this study, Sheehan et al incorporated all type III tibia injuries (including IIIA and IIIB injuries). The MESS was not designed and is it applicable to tibia fractures without an associated vascular injury. It would however be valuable to assess a subgroup analysis of the MESS score in those combat patients with type IIIC

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tibia fractures, to see if there is any improvement in the performance of the score, when it is applied as indicated.

The MESS score does not perform well for all combat-related type III tibia fractures; however, there may remain a role for the MESS in type IIIC tibia fractures.

**David L. Helfet, MD**

**David C. Dewar, MD**

Orthopaedic Trauma Service, Hospital for  
Special Surgery and New York Presbyterian Hospital,  
New York, NY.

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