

Reliability of the mangled extremity severity score in combat-related upper and lower extremity injuries

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ABSTRACT

Background: Decision of limb salvage or amputation is generally aided with several trauma scoring systems such as the mangled extremity severity score (MESS). However, the reliability of the injury scores in the settling of open fractures due to explosives and missiles is challenging. Mortality and morbidity of the extremity trauma due to firearms are generally associated with time delay in revascularization, injury mechanism, anatomy of the injured site, associated injuries, age and the environmental circumstance. The purpose of the retrospective study was to evaluate the extent of extremity injuries due to ballistic missiles and to detect the reliability of mangled extremity severity score (MESS) in both upper and lower extremities.

Materials and Methods: Between 2004 and 2014, 139 Gustillo Anderson Type III open fractures of both the upper and lower extremities were enrolled in the study. Data for patient age, fire arm type, transporting time from the field to the hospital (and the method), injury severity scores, MESS scores, fracture types, amputation levels, bone fixation methods and postoperative infections and complications retrieved from the two level-2 trauma center's data base. Sensitivity, specificity, positive and negative predictive values of the MESS were calculated to detect the ability in deciding amputation in the mangled limb.

Results: Amputation was performed in 39 extremities and limb salvage attempted in 100 extremities. The mean followup time was 14.6 months (range 6–32 months). In the amputated group, the mean MESS scores for upper and lower extremity were 8.8 (range 6–11) and 9.24 (range 6–11), respectively. In the limb salvage group, the mean MESS scores for upper and lower extremities were 5.29 (range 4–7) and 5.19 (range 3–8), respectively. Sensitivity of MESS in upper and lower extremities were calculated as 80% and 79.4% and positive predictive values detected as 55.55% and 83.3%, respectively. Specificity of MESS score for upper and lower extremities was 84% and 86.6%; negative predictive values were calculated as 95.45% and 90.2%, respectively.

Conclusion: MESS is not predictive in combat related extremity injuries especially if between a score of 6–8. Limb ischemia and presence or absence of shock can be used in initial decision-making for amputation.

Key words: Amputation, combat injuries, lower extremity, mangled extremity severity score, upper extremity

MeSH terms: Open fractures, amputation, lower extremity, upper extremity

INTRODUCTION

The predominance of extremity trauma during combat zone is reported as high as 54% and is well documented.^{1,2} Injuries are generally due to explosives and high-energy missiles and are usually

accompanied with open fractures and neuro-vascular impairment. Decision of limb salvage or amputation is generally aided with several trauma-scoring systems such as the mangled extremity severity score (MESS).³ However, the reliability of the injury scores in the settling of open fractures due to explosives and missiles is challenging.⁴ Mortality and morbidity of the extremity trauma due to firearms are generally associated with time delay in revascularization, injury mechanism, anatomy of the injured site, associated injuries, age and the environmental circumstance.^{5,6} The aim of this retrospective study was to report the incidence

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of extremity traumas due to firearms and explosives and to evaluate the predictive value of MESS criteria in open fractures for both upper and lower extremity due to firearm injuries.

MATERIALS AND METHODS

317 patients with various ballistic extremity traumas who were referred to two different level-2 trauma centers between 2004 and 2014 were enrolled in this retrospective study. Data for patient age, fire arm type, transporting time from the field to the hospital and the method, injury severity scores (ISS), MESS scores, preoperative patient status, fracture types, amputation levels, bone fixation methods and postoperative infections and complications were retrieved from the hospital's database.

All patients were transported with helicopter from the battle field to the hospital on the same day. On admission to the emergency department, all resuscitative measures were followed according to the advanced trauma life support. Limb salvage was attempted in patients with repairable vascular injuries, viable soft tissues in injured extremity and in those who had adequate soft tissue for coverage of open fractures. Bony fractures were fixed either with external or internal fixation methods. In case of extensive soft tissue defects, late wound closure was chosen. Serial wound washout and debridements were performed every 2–3 days when required. Serial wound cultures were taken and appropriate antibiotics were given. Penetrating fragments without neurovascular impairment were treated with simple irrigation and debridement. Intraarticular penetrating fragments were excised. The value of 7 or above for MESS was used as a cut-off value to decide amputation or limb salvage as this score was previously reported as reliable predictor for amputation.³ To determine the ability of MESS scoring system to predict amputation, specificity, sensitivity and positive-negative predictive values were calculated. Thus, cases were re-grouped according to the following criteria to assess the reliability of the MESS: (a) Mangled lower or upper extremity, (b) Gustilo Anderson Type-III (a, b, c) fractures of femur, tibia, forearm or humerus, severe muscle damage, associated nerve injury and major blood loss, displacement of more than 50% and comminuted and segmental fracture.

Patients with near amputation limbs with a small bridge of soft tissue connecting the distal extremity, isolated foot and hand digit injury and amputations were excluded.

Sensitivity was calculated by dividing the number of amputees with scores at or above the cut-off value with the total number of amputated patients. Specificity was described by dividing number of salvaged extremities with a score below cut-off value to the number of salvaged

extremities. Positive predictive value was described by dividing the number of amputated extremities with scores at or above the threshold level to the total number of extremities with scores at or above the threshold level. Negative predictive value was calculated by dividing the number of salvaged extremities with scores below the threshold level to the total number of extremities with scores at or below the threshold level. MESS scores for each group was compared using Wilcoxon test. Components of the MESS were compared using Fisher's exact test. Statistical significance was set at $P < 0.05$.

RESULTS

The mean followup time was 14.6 months (range 6–32 months). Vast majority of patients were due to explosives rather than gunshots ($n = 238/79$). All patients were transported from the initial field to the hospital within 1 h to 8 h period. Soft tissue injuries (without bony fractures) due to penetrating fragments were seen in 54.8% of the patients ($n = 174$) and rest of patients ($n = 143$) had bony injury. In most of the soft tissue cases (42%) both lower and upper extremities were affected. Soft tissue injuries due to penetrating fragments, accompanied with neuro-vascular injury were detected in 17 patients. Vascular injuries ($n = 9$ and in all of the patients MESS score < 7) were treated simultaneously by a cardiovascular surgeon. Limb viability was achieved and none of the patients needed amputation. Penetrating fragment excision was performed in 44 patients in whom foreign bodies were in close approximation of the neurovascular structures ($n = 39$) or with intraarticular location ($n = 5$). Simple debridement and irrigation was performed in the rest of the patients. In the followup period, infection occurred in 12 patients and appropriately managed with broad-spectrum antibiotics, debridement and removal of penetrating fragments.

There were 157 bone fractures in 143 patients, 139 of which were open (17 in upper extremity/122 in lower extremity) [Table 1]. Amputation was chosen in 39 of the severely injured extremities [Figure 1]. The mean age of patients in both groups (limb salvage/amputation) was 24.6 years. Most of the amputations were done for the lower extremity ($n = 34$) and all of them caused by explosives rather than GSW. There was no statistically significant difference between amputated and limb salvage group

Table 1: Patient demographics and Gustilo-Anderson classification

Extremities	Number (upper/lower extremity)	Patient age (mean in years)	IIIA (Upper/lower limb)	IIIB	IIIC
Total	139 (17/122)	24.6	10/29	11/39	9/41
Amputated	39 (5/34)	25.1	0/0	1/6	4/28
Salvaged	100 (25/75)	24.2	10/29	10/33	5/13

in terms of age ($P > 0.05$). In the amputated group, the mean MESS scores for upper and lower extremity were 8.8 (6–11) and 9.24 (6–11), respectively. ISS scores for lower and upper amputated groups were 19 and 16.6, respectively. One patient in the upper extremity group and seven patients in lower extremity group with a MESS score below 7 needed amputation after unsuccessful attempt (due to severe infection and necrosis after period of 7–15 days) at salvage. These eight patients had concomitant upper/lower extremity injuries and significantly higher mean ISS scores compared to others (23.6 vs. 19.7 [$P < 0.05$]). Thus, the sensitivity of MESS in upper and lower extremities was calculated as 80% and 79.4% and the positive predictive values were 55.55% and 83.3%, respectively. In five amputated patients, below knee level was revised to above knee due to stump necrosis and infection. Limb salvage was performed in 100 (25 in upper extremity, 75 in lower extremity) extremities. Neuro-vascular impairment was detected in 18 patients. Vascular repair performed in all

limb salvage group by cardiovascular surgeon and limb viability assessed [Figure 2]. In the limb salvage group, the mean MESS scores for upper and lower extremities were 5.29 (4–7) and 5.19 (3–8); the ISS scores were 10.3 and 9.4, respectively. These scores were significantly different from the amputation group ($P < 0.05$). Specificity of MESS score for upper and lower extremities was 84% and 86.6%; negative predictive values were calculated as 95.45% and 90.2%, respectively. Our results are summarized in Table 2. When we analyze the components of MESS with Fisher's exact test, amputation was strongly associated with prolonged hypotension and arterial injury. Although all the amputated patients had high-energy trauma due to explosives, majority of extremities in these patients had been salvaged.

DISCUSSION

Management of the mangled limb due to firearms and explosives remains unclear for many orthopedic surgeons.^{2,4,5} Newer techniques in bone fixation, vascular reconstruction and soft tissue coverage allow limb salvage even in the severely injured extremities. However, multiple operative procedures, prolonged rehabilitation and physiologic problems must be regarded.^{4,6,7} Several traumascoring systems for deciding limb salvage or amputation have been developed. However, none of them had been clearly validated even in civilian and combat settling.⁴ In 1990, Johansen *et al.*³ first developed MESS scoring system in a retrospective study containing 25 casualties with vascular and orthopedic injuries to decide limb salvage or amputation in mangled limbs. They proposed that a MESS of equal or >7 can be used to decide amputation. They

Table 2: Distribution of MESS values

Extremities	Upper extremity	Lower extremity	Total
Number	17	122	139
Amputated extremities	5	34	39
MESS ≥ 7	4	27	31
MESS < 7	1	7	8
Salvaged extremities	25	75	100
MESS ≥ 7	4	10	14
MESS < 7	21	65	86
Sensitivity (%)	80	79.4	
Specificity (%)	84	86.6	
Positive predictive value (%)	50	72.9	
Negative predictive value (%)	95.45	90.2	

MESS=Mangled extremity severity score



Figure 1: (a) Clinical photograph of a 21-year-old man who sustained firearm injury due to landmine showing that the left fore-foot and mid-foot were severely injured. The preoperative mangled extremity severity score was 9 (b) Clinical photograph of same patient showing syme's amputation

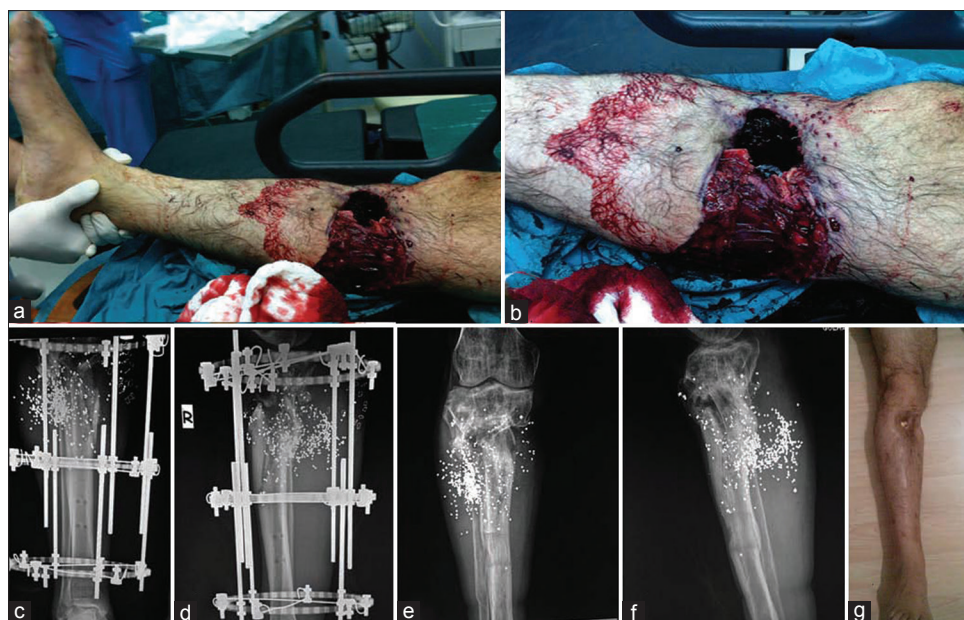


Figure 2: (a and b) Clinical photographs of a 41-year-old man who sustained gunshot injury to the right leg showing arterial lesion, hypotension, with a mangled extremity severity score of 8 (c and d) X-ray anteroposterior and lateral views of leg bones showing external fixator was applied after arterial repair and serial debridement performed thereafter. (e and f) Plain radiographs anteroposterior and lateral view showing bony union. (g) Clinical photograph at 2 years followup showing healed wound

have validated their finding in a further prospective study containing 26 limbs with a predictive value of 100%.⁸ They have reported MESS values for salvaged and amputated limbs as 2.44 and 7.87, respectively. However, sample size in that study was relatively small and fewer extremities had a MESS score between 5 and 8. Beside the threshold level of 7 had been approved in some studies.^{9,10}

In the current study which contains larger and homogenous patient group compared to previous studies, we have investigated the reliability of MESS specifically for ballistic injuries of both the upper and the lower extremities. Our study showed that there was a statistically significant difference in terms of MESS between patients (both upper and lower extremity) who had been primarily amputated and those who had attempted salvage. The most important MESS component related with amputated extremities was arterial injury and hypotension. These can be regarded as primary indications for amputation in the military environment and this finding is consistent with the current literature.^{4,11}

However, we have found lower sensitivity, specificity, positive and negative predictive values compared to available literature reports that validate MESS.^{3,8-10} This discordance was due to some factors. We have eight cases who needed amputation (1 upper extremity, 7 lower extremity) with a MESS score of 6 after unsuccessful limb salvage. All of these cases had concomitant upper/lower extremity trauma with a higher mean ISS scores. Ten extremities (4 in the upper extremity group, 6 in lower

extremity group with a mean MESS of 7.6) equal or higher than threshold level had been successfully salvaged in the limb salvage group. According to our results, there was an overlap in the MESS range 6–8 that can be defined as a critical zone to decide whether limb salvage or amputation should be attempted.

Recently, the Lower Extremity Assessment Project study which consists of 556 high-energy lower extremity injuries showed high specificity but lower sensitivity than the previous reports.⁶ Sheean *et al.*² in their retrospective cohort study containing 155 patients with combat-related open tibial fractures found no significant difference between MESS scores of amputated patients and those with limb salvage. Brown *et al.*⁴ reported predictivity of the MESS in large number of patients (86 limbs) with lower extremity injuries due to firearms sustained in the combat zones. They have founded the positive predictive value of the MESS as 64.3% and specificity and sensitivity as 84.4% and 85.7%, respectively. These are in accordance with our findings.

Literature consists of limited number of studies about the reliability of MESS in mangled upper extremities as this scoring system was originally designed to assess injuries to the lower limb. Slauterbeck *et al.* stated that MESS is a reliable predictor of amputation in severely injured upper extremity in their series containing 43 open fractures.¹² However, Togawa *et al.* concluded that MESS of 7 points does not appear to be appropriate in deciding amputation in upper extremities.¹³ In the current study, we have found a lower specificity, sensitivity, positive and negative predictive

values for MESS in upper extremity injuries similar to the results in the lower extremity.

We think that combat-related injuries to the extremities are specific and somewhat different from civilian events. In general, this patient cohort is young and has concomitant multiple organ injuries. Furthermore, the prevalence of blast injuries is frequent. Blast injury cause extensive tissue destruction which may not be noted in the first stage of the trauma. For these factors, treatment choices in combat-related injuries may not be transferred to the civilian practice and makes inconsistency in the application of the MESS to the mangled extremity.

Our study has some limitations as we have relatively short followup. However, we think that higher number of patients within our study when compared to the literature is the strength of our study.

We conclude that the MESS is not predictive in the setting of combat related extremity injuries especially between a score of 6–8 in both upper and lower extremities. However, limb ischemia; presence or absence of shock and concomitant injuries in other extremities can be used in initial decisionmaking for amputation.

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Conflicts of interest

There are no conflicts of interest.

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