VALIDATION OF MANGLED EXTREMITY SEVERITY SCORE IN ASSESSING THE NEED FOR EXTREMITY AMPUTATION

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ABSTRACT

INTRODUCTION: The decision to either salvage or amputate a mangled extremity poses great challenge to a surgeon. Different scoring systems were therefore developed to aid orthopaedic surgeons in this decision, either to contemplate amputation or proceed to salvage a mangled extremity. Of these scoring systems, the mangled extremity severity score (MESS) is mostly used. However, the high predictive accuracy reported by its developers has not been replicated by other authors. This study was carried out to validate the use of this scoring system in Nigeria and by extension, Africa.

PATIENTS MATERIALS AND METHOD: The study was a hospital based prospective descriptive one which studied all patients with mangled extremities that were admitted into the Accident and Emergency room of the Lagos University Teaching Hospital (LUTH), Idi- Araba, from April 2014 to March 2015. Injured patients with mangled extremities were resuscitated and relevant investigations conducted. The MESS was calculated at presentation in the emergency room by two senior doctors in orthopaedic and trauma units (not lower than senior registrar cadres) independently and an average score calculated, rounded up to the nearest positive integer and documented. Type of treatment offered was based on the experience of the managing consultants. Patients' progresses were monitored and functional outcomes documented. All data generated during the study were analysed using Statistical Package for the Social Sciences (SPSS Inc. Chicago, Illinois. version 21.0. Year of release - 2012).

RESULTS: Twenty-nine mangled extremities in 27 patients were studied. The male: female ratio was 3.5:1. Age of patients ranged between 21-70 years with a mean age of 39.9 ±12.3years. Nineteen (65.5%) extremities were salvaged while 10(34.5%) were primarily amputated. Average MESS of all mangled limbs reviewed was 8.1 ± 2.6 with scores that ranged from 3 to 13. The mean MESS for limb salvage was 7.0 +2.2while that for primary amputation was 10.1 ± 2.0(P value- 0.01). MESS in this study had a sensitivity of 90%, specificity of 47.4%, positive predictive value of 47.4%, negative predictive value of 90%. AUROC in this study was 0.853. The cost of treatment, number of surgeries, and duration of hospital stay were higher in those with Salvaged limbs. The functional outcome for salvaged upper and lower extremities were better than for those whose limbs were amputated. Level of satisfaction was better in the limbs salvaged group than for those who had ablative surgery with statistical significance (P value- .000).

CONCLUSION: This study validated the clinical utility of MESS in predicting the need for amputation in patients with mangled extremity injuries but it had a low predictive accuracy for extremities that would eventually enter the limb salvage pathway. Therefore, when contemplating limb salvage for a patient with mangled extremity, in addition to the result of the MESS score, the surgeons experience cannot be overemphasized.

KEYWORDS: Open fracture, mangled limb, amputation, MESS score, classification

INTRODUCTION

A mangled extremity is a limb with an injury to at least three out of four systems (soft tissue, bone, nerves and vessels).[1] It has historically been associated with very high amputation rates.

Mangled extremities almost by definition involve a wide spectrum of injuries from the easily manageable to the barely salvageable (mangled extremity).[2] Mangled extremity usually result from high energy trauma which leads to combined bone and soft tissue injury with associated severe bone and soft tissue destruction or loss. Its treatment poses a major challenge and the decision whether to amputate or attempt reconstruction is mostly based on surgical evaluation. While amputation could be less expensive and less risky than limb salvage, the acceptability of ablative surgery may not be cultural compactible amongst Africans. Of note, also, is that failed efforts at limb salvage and reconstruction are associated with increased patient mortality and high hospital costs. To

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help guide this decision on the form of treatment to offer, extremity injury severity scoring systems were developed. Attempts to qualify the severity of the trauma and to establish numerical guidelines to guide whether to amputate or salvage the limb have been proposed by several authors. However, the evidences for their sensitivity and specificity were rather inconclusive.[3]

Published severity scoring systems of lower extremity injury include the Mangled Extremity Severity Scale (MESS)[3]; the Predictive Salvage Index (PSI)[4]; the nerve injury, ischemia, soft tissue injury, skeletal injury, shock, age of patient score(NISSSA)[5] and Mangled Extremity Syndrome Index(MESI) score[6]. Of these scoring systems, MESS is the most widely applied because of its simplicity.[7-10.] MESS has few variables, does not need extensive operative evaluation, and is easy to apply. MESS was based on four clinical criteria: skeletal/soft tissue injury, limb ischemia, shock and age. A point system was developed to grade the severity of each of the four criteria. The development of MESS was based on retrospective review of 26 injured limbs. Moreover, a prospective trial to validate the proposed scoring system was done in a separate trauma centres using other patients. They concluded that a MESS score of less than 7 predicted salvageable limb with 100% accuracy and a MESS score of equal or more than 7 predicted amputation with 100% accuracy. However, independent testing of MESS by other authors had varying reports. Though some authors reported good accuracy of MESS[2, 11-13.] Others could not duplicate the successes as reported by the developers of MESS.[14-16]

There is paucity of report of validation of this scoring system in Nigeria. Most of the available researches on the MESS were reported in other continents. Few data on exist in Africa. Report has also shown difficulty in applying MESS universally especially in resource poor setting like Nigeria because the management of these severe injuries is influenced by other factors such as surgical skills and experience of the managing team, in addition to the social and cultural background of the patient.[2]Elsharawy[17], in his reported was able to salvaged 93.4% of limbs with MESS >7, but Kumar [13] in India reported a salvage rate ten times lower (9.09%), even though the number of cases in these studies are almost equal (62 and 61, respectively).

This study was conducted to have a view on clinical relevance of MESS in our practice. It was also to help in determining the sensitivity and specificity of MESS in our environment and to determine if the threshold of a score of 7 for MESS is applicable in our environment. We hope that our findings will assist orthopaedic surgeons in our region in making appropriate

decisions either to save limbs or amputate whenever necessary as misjudgment may either result in unnecessary amputation of viable limb or secondary amputation after failed salvage[18].

METHODOLOGY
The study was a hospital based prospective descriptive study which studied all patients with mangled extremities that were admitted into the Accident and Emergency room of the Lagos University Teaching Hospital (LUTH), Idi- Araba, from April 2014 to March 2015. The necessary ethical approval was obtained. The study was explained to the patients and their consent obtained. The injured patients were resuscitated in line with Advanced Trauma Life Support (ATLS) protocol in the accident and emergency room. All data were recorded into a proforma. Patients with Complete traumatic amputation and those with isolated foot or hand crush injury were excluded from this study. Radiological investigations which included plain X-Ray to determine the fracture morphology and angiography in selected cases with vascular injury were conducted. Extremities in the limb salvage pathway were debrided and fractures stabilized; soft tissue cover and vascular repair were performed in conjunction with plastic surgeons and vascular surgeons respectively where indicated.

The MESS was calculated at presentation in the emergency room by two senior doctors in orthopaedic and trauma units (not lower than senior registrar cadres)independentlyto eliminate bias and an average score calculated, rounded up to the nearest positive integer and documented. Multiple seminars were conducted to train the personnels involved prior to the commencement of this study.

To calculate the Mangled Extremity Severity Score, four significant criteria used were skeletal/soft-tissue injury, limb ischemia, shock, and patient age. After calculating the score, the option of treatment offered, of either primary amputation or salvaging a limb was then based on the clinical judgement of constellation of senior consultants in orthopaedic, plastic and vascular surgeries. Patients' progresses were monitored and outcomes of the treatment offered were documented. All patients were followed up for at least 3-months to assess the outcome. The functional outcomes for upper and lower extremities were assessed with upper extremity functional scale[19]and lower extremity functional scale[20] respectively. Complications were also noted. The functional outcome of mangled extremity was correlated with the MESS at presentation.

Data analysis
All data generated during the study were analyzed

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using SPSS statistical software version 21(2012). Results were presented in tables and charts. Association between variables was determined using Pearson Chi-square test (two tail) with level of significance set at 0.05(P< 0.05).

RESULTS

Twenty-seven (27) patients with 29 mangled extremities were studied. Age of patients ranged. From 21-70 years with a mean age of 39.9 $\pm$ 12.3 years. Most of the patients (66.7%) were in the average of 21-40 years. Most of the patients were males with male:female ratio of 3.5: 1.Road traffic incident involving pedestrians was the commonest (48.2%) cause of mangled extremities followed by motorcycle accidents and gunshot injuries accounting for 18.5% apiece(Figure 1). Mangled extremities occurred more commonly (77.8%) in lower limbs than those involving the upper extremities (22.2%).The mean MESS of the mangled limbs studied was of 8.1 $\pm$ 2.6 with scores ranging from 3 to 13. Nineteen extremities had a MESS > 7 while 10 extremities had a score < 7. The mean MESS in the group where limb salvage procedures were done was 7.0 $\pm$ 2.2 compared with a mean MESS of 10.1 $\pm$ 2.0 for primary amputation (P value- 0.01) as depicted in table 1. Nineteen (65.5%) extremities were salvaged while 10 (34.5%) limbs were primarily amputated. (Table 2) Overall, average time of surgical Intervention was 1.78±0.80 hours. Average time of surgical intervention for salvaged and amputated extremities was 1.84 $\pm$ 0.83 hours and 1.63 $\pm$ 0.74 hours respectively.

Mangled extremity severity score (MESS) in this study had a sensitivity of 90%, specificity of 47.4%, positive predictive value of 47.4%, negative predictive value of 90%.The receiver operating characteristic (ROC) MESS was calculated and the area under the curve (AUC) was calculated to obtain the objective performance of the scoring system. (Figure 2) Area under the receiver operating characteristic (AUROC) in this study was 0.853 which meant that, in 85 of 100 cases, a randomly selected individual from among those with amputation had a larger value MESS than a randomly chosen individual among those whose limbs were successfully salvaged.

(Table 3)

Majority (94.7%) of patients with salvaged extremity had more than one surgery compared to 37.3% of the amputated group who had more than one surgery. (Table 4)The mean number of surgeries for limb amputation and salvage were 1.4 and 2.3 surgeries respectively. (P value-0.01)Patients who had their limbs salvaged spent more time (16 – 20 weeks) on admission than the amputated group who spent maximum of 8 weeks (P value-0.001).

The mean functional score for salvaged lower extremity (54.5%) was higher than the amputated group (40.5%). Also, the lower extremity functional score had a higher mean value (55.8%) in patients with MESS score <7 compared to the mean functional score (47.0%) in patients with MESS > 7. (P value- 0.114)The mean functional score for salvaged upper extremity (41.9%)was higher than amputated group (4.5%).(P value- 0.02) Patients with MESS score <7 has higher mean values (93.8%) than those with MESS   7 with mean functional score of 14.5%

The limb salvage group spent between 2,105-3,157 United States(US) dollars while those that were amputated spent <1,052 US dollars on treatment (Exchange rate of 1US dollar to 190 naira)(Table5). (P value- 0 .000) Overall, 83.3% of patients with salvaged extremity and 16.7% of amputees' were satisfied with the mode of treatment. (Table 6) (P value - 0.03)

DISCUSSION

There was a preponderance of male patients. This was not far-fetched because young males are adventurous and highly mobile engaging in high velocity travels more frequently than their female counterpart. This finding was in consistent with the findings by both Ngimet al[21] and Adegbehingbe et al.[22] The major mechanism of injury was pedestrian road traffic accident followed by gunshot injuries and motorcycle accident. Injury is immediate damage inflicted on the body as a result of energy exchange. It is, therefore, not surprising as the above mentioned mechanisms of injury are associated with high energy transfers, thereby causing tremendous damage to the limb leading to mangled limbs. Other study in the subregion noted similar finding.[22]

The mean MESS of salvaged limbs was 7.0 $\pm$ 2.2 while that of amputated limbs was 10.1 $\pm$2.0(p value - 0.01). This was at variance with values reported by Kumar and co-workers[13] whose mean MESS score for salvage and amputated extremity to be 4.65 and 8.8 respectively. Robertson[23] suggested that inter-observer differences, especially when assigning scores to the 3rd and 4th parameters of skeletal and soft tissue injury component of this scoring system may be responsible for this difference.[23]This inter-observer difference was the reason the MESS was calculated by 2 senior orthopaedic surgeons and the mean (rounded to the nearest integer) taken as the MESS score used for this study.

The sensitivity and specificity of MESS in this study was 90% and 47.4% respectively. The negative predictive and positive predictive values were 90% and

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47.4% respectively. The high sensitivity and low specificity of MESS in this study implied that MESS has high accuracy to detect extremities that required amputation and it was able to accurately predict limb salvage in approximately half of the cases . This may result in unnecessary limb amputation in limbs that would have been successfully reconstructed. The low specificity for MESS resulted from the fact that ten of the nineteen patients (52.6%) that had limb salvage had a score>7. The low specificity and high sensitivity of MESS recorded in this study was similar to the results published by Rajasekaran et al[2] in India where MESS had a poor specificity of 17% and high sensitivity of 99%[2]. However, it was at variance with the high specificity in a similar study recorded by Helfet and colleagues[24] working in the Western world. The area under receiver operating characteristics (AUROC) for this study was 0.853 meaning that, in 85 of 100 cases, a randomly selected individual from among those who had limb amputation will have a larger MESS value than a randomly chosen individual among those whose limb were successfully salvaged. Generally, areas under the curve of less than 0.70 represent poor discrimination; values of 0.70 to 0.90, moderately good discrimination; and values greater than 0.90, excellent discrimination.[25,26]

Patients with successful limb salvage had undergone more than one operative procedures, spent more days in the hospital, incurred higher hospital charges but better mean functional scores than those who underwent primary amputation. This finding was corroborated by other author.[27] The mean functional score for salvaged upper extremity was higher than amputated group. This is attributed to the fact that upper limb prostheses do not restore function to the same extent as lower limb prosthesis.[27, 28]Amputated lower extremity also had a lower mean functional outcome score when compared to salvaged lower extremities. However, it was at variance with findings by authors in Western part of the world.[27,29,30,31] This may be linked to the fact that most of the prosthesis used here are locally fabricated and are not as sophisticated and functional as those produced in the western world.[8,29]

For cultural and practical reasons, Africans prefer to retain their own limb, even though deformed, provided it is painless and retains some function[32].In this study,83.3% of patients with salvaged extremity and 17.7% of amputees' were satisfied with the mode of treatment. Rajasekaran[33] and Udosen[32] also noted similar findings. This is because amputation carries a stigma and serves as a mode and mark of punishment for certain offenders in some parts of Africa, and some religious belief. It is also believed to recur with re-incarnation.[34,35]

Non-availability and non-affordability of the state of the art prostheses for amputee patients in developing countries may also be responsible for poor satisfaction. In this study, it was found cost of treatment was significantly higher in patients who had their limbs salvaged when compared to those who had an amputation (P value- .000).This finding was similar the result of a study by Georgiadiset al[36]. Cost of surgical intervention can be a major limiting factor when considering limb salvage for a patient with mangled extremity especially in resource poor parts of the world.

CONCLUSION
This study validated the clinical utility of MESS in predicting the need for amputation in patients with mangled extremity injuries but it had a low predictive accuracy for extremities that would eventually enter the limb salvage pathway. MESS mangled extremity severity score is useful as a screening test to support an amputation but is incapable of accurately identifying patients that would enter the limb salvage pathway. In conclusion, MESS should be used to complement the surgeon's clinical judgment and experience especially when contemplating limb salvage in patients with mangled extremity.
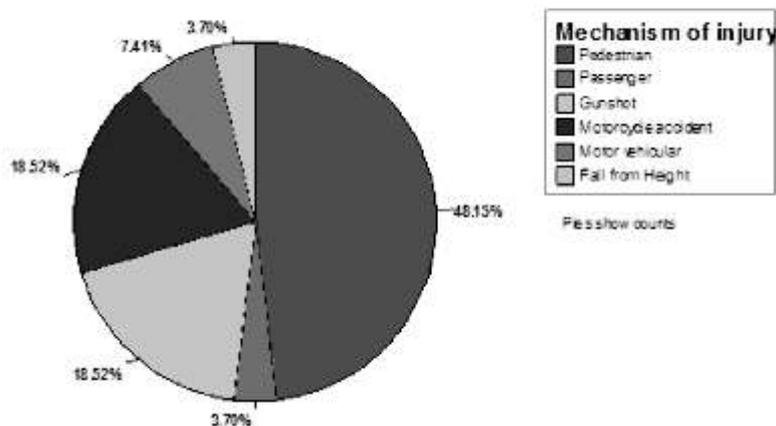
Figure 1: Mechanism of injury

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Table 1: Mean MESS Score

Treatment	Number of extremities	Mean MESS (SD)	p value
Salvage	19	7.0 ± 2.2	0.01
Amputation	10	10.1±2.0	

Table 2: MESS Score and procedure performed

MESS	Treatment		Total
	Amputated extremities	Salvaged extremities	
MESS ≥7	9(True Positive)	10(False positive)	19
MESS <7	1(False Negative)	9(True Negative)	10
Total	10	19	29

Sensitivity 90%, Specificity 47.4%, PPV 47.4%, NPV 90%

ROC Curve

Diagonal segments are produced by ties.
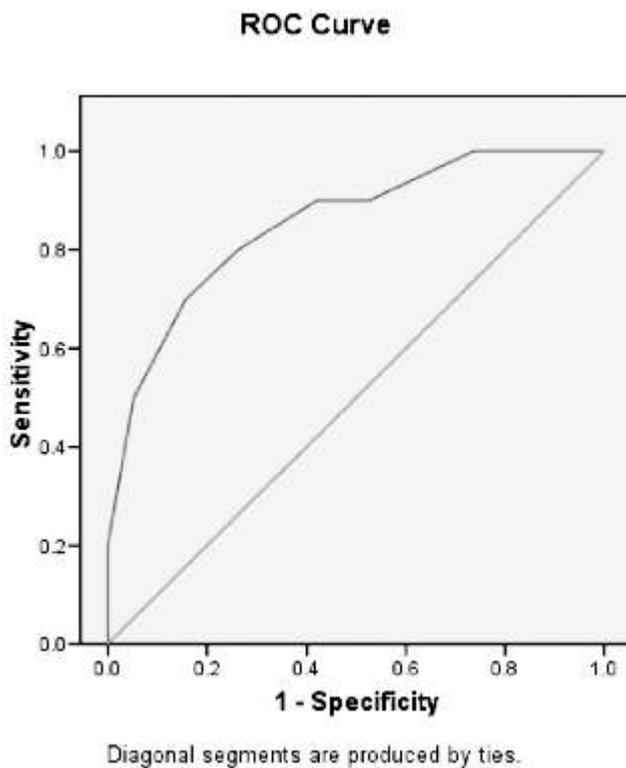
Figure 2: Receiver operating characteristics curve

TABLE 3: Area under the curve
Test result variable(s): mangled extremity severity scores at presentation

Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
.853	.075	.002	.705	1.000

TABLE 4: Relationship between treatment and number of surgical procedures

Treatment	Number of surgical procedures				Total	Mean	p-value
	1	2	3	4			
Salvaged	1(5.3%)	13(68.4%)	4 (21.1%)	1(5.3%)	19	2.3	0.010
Amputated	5 (62.5%)	3 (37.3%)	0 (0%)	0 (0%)	8	1.4	
Total	6	16	4	1	27		

TABLE 5: Relationship between treatment option and cost of treatment

Cost of treatment in US dollars	Treatment		Total	p-value
	Salvaged	Amputated		
< 1,052	0	6(75%)	6	.000
1,052-2,105	0	2(25%)	2	
2,105-3,157	8(42.1%)	0	8	
3,157-4,210	7(36.8%)	0	7	
>4,210	4(21.1%)	0	4	
Total	19(100%)	8(100%)	27	

TABLE 6: Relationship between treatment and patients' satisfaction

Treatment	Patients satisfaction		Total	p-value
	Yes	No		
Salvage	15(83.3%)	3(17.7%)	18(100%)	0.03
Amputation	1(16.67%)	5(83.33%)	6(100%)	
Total	16	8	24	

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