ORIGINAL ARTICLE

Comparative Evaluation of Diagnostic Accuracy of MESS and PSI in Lower Limb Amputation Following Trauma Presenting at the National Orthopaedic Hospital, Dala Kano

Yakubu Surajuddeen[1], Abdurrahman Alhaji Mamuda[2*], Bashir Bello[3]

ABSTRACT

Background: Mangled Extremity Severity Score (MESS) and Predictive Salvage Index (PSI) are two common diagnostic tools used to assess traumatic limb for amputation or salvage. However, there is paucity of local data with regards to accuracy of the tools. **Objective:** This study is therefore aimed at comparing the accuracy and predictive value of MESS and PSI in lower limb salvage and amputation following trauma in National Orthopaedic Hospital Dala (NOHD), Kano. **Methodology:** Twenty-three individuals with mangled extremity participated in this hospital-based one-year prospective, interventional study. Socio-demographic data of participants were collected and recorded as well as the severity of the injury at the time of initial presentation using both MESS and PSI by the researcher while the Consulting surgeons went ahead to make their decision as per their clinical routine without any influence from the researcher. **Results:** Findings of the study showed that MESS has a high sensitivity score of 89% and a low to medium specificity score of 43.8% with a positive predictive value (PPV) of 47.1% while PSI had a high specificity with low to medium sensitivity scores of 81.25% and 55% respectively with a PPV of 62.50%. **Conclusion:** The result of this study showed that MESS had high sensitivity and low specificity than PSI which had higher specificity and lower sensitivity than MESS in predicting amputation and limb salvage in patients with mangled lower extremity injuries. It is, therefore, recommended that surgeons should use both tools in decision making of limb salvage and amputation for optimal outcomes.

Keywords: Mangled extremity, Limb Salvage, Amputation, Diagnostic tools, Accuracy.

[1]National Orthopaedic Hospital, Dala, Kano
[2]Dept of Surgery, Faculty of Clinical Sciences, Bayero University Kano
[3]Dept of Physiotherapy, Faculty of Allied Health Sciences, Bayero University Kano

Corresponding Author:
Dr Mamuda, A.A
Department of Surgery (Orthopaedic Unit),
Email: nurubash@gmail.com Phone No: 08065567819.

Access this article online

Quick Response Code

website: www.bornomedicaljournal.com

DOI: 10.31173/bomj.bomj_148_16

Introduction

Severe trauma to the lower extremity presents challenges with regards to reconstruction and rehabilitation.[1] Mangled extremity is a limb with an injury to at least three out of four systems; soft tissue, bone, nerves and vessels.[2] The decision to amputate or salvage a severely injured lower extremity is difficult.[1] Numerous scores have been proposed to provide guidelines to the attending surgeon, notable of which are mangled extremity severity score (MESS), the predictive salvage index (PSI) and others. However, independent testing of some of these scoring systems has not duplicated the success reported by the developers of these systems.[3-5] The mangled extremity severity score

(MESS) developed by Johansen, *et al*[6] evaluates four important variables: degree of injury to the tissues, presence and duration of shock, age of the patient, the severity and duration of limb Ischemia. Johansen, *et al*[6] reported that a score of 7 or more predicted amputations with 100% accuracy. The proposed advantage of this predictive index is that the information is readily available upon presentation, its relative simplicity and reproducibility.[7] Generally, MESS is highly specific, suggesting that it might be useful in predicting limbs that should not undergo amputation.[8] The low sensitivity, however, suggests that a large proportion of limbs eventually requiring amputation would be at risk of delay in the procedure, and this delay might in turn be associated with complications.[8]

The predictive salvage index (PSI) was introduced by Howe *et al*[9] to assess the condition of patients with combined orthopaedic and vascular injuries. The intent of PSI was to help prevent the attempted salvage of a doomed or useless limb. It evaluates the level of the vascular injury, the degree of osseous injury, the degree of muscle injury, and the warm ischemia time. Howe, *et al*[9] reported a sensitivity of 78% and specificity of 100% in their cohort of patients. The main aim was to avoid an unnecessary or a delayed amputation of a limb. The study was based on a retrospective analysis of a small group of 21 limbs, which analyzed the variable factors that determined amputation or salvage in that group. The variables that were given importance were the extent of vascular injury, the degree of bone damage, the degree of injury to the muscles, and the warm ischemia time. However, independent testing of this scoring system has not duplicated the success reported by the developer. It has been flawed by its retrospective design and small sample size. Another problem with PSI system of scoring is that there are no clear boundaries on the severity of soft tissue and bone injuries, which is only described as mild, moderate and severe. Obviously, this will lead to different interpretation by different doctors. The import of these two predictive scoring systems is that they enable surgeons to know when to amputate and when to salvage.

While there have been several reports regarding the satisfactory application of predictive MESS and PSI scores in lower limb amputation, the optimal scores remain controversial. A Major factor in the decision-making in the treatment of mangled extremity is the risk of major complications like infection, non-union, osteomyelitis, post traumatic arthrosis, wound necrosis or break down and phantom pain. Knowledge of MESS predictive value will aid to predict necessity of amputation after lower extremity trauma. This study aimed to compare the predictive value of MESS and PSI in lower limb amputation following trauma.

Methodology

This study was a hospital based one-year prospective, interventional study aimed at comparing predictive value of MESS and PSI in lower limb amputation following trauma in National Orthopaedic Hospital Dala (NOHD), Kano. The study was conducted on patients that presented to the Accident and Emergency unit of NOHD, who met the inclusion criteria and consented to participate.

The inclusion Criteria include:

1. Patients that presented with mangled lower extremity following trauma
2. Open extremity fractures

3. Shredded muscle and transected posterior tibia nerve
4. Associated mangling or severe injury to ipsilateral foot.

Individuals were excluded if they had any of the following;

1. Complete traumatic amputation.
2. Patient who refused to give consent.
3. Patient who had amputation in other hospital before presenting for refashioning.

Sample size

The estimated sample size was calculated using the Yamane[10] formula;

$$\text{Sample size (n)} = \frac{N}{1+N\,(e^2)}$$

Where: N = Population Size

e = level of precision 0.05

Pilot study conducted at the National Orthopaedic Hospital, Dala Kano showed that 22 mangled lower extremities were amputated over a one-year period.

$$n = \frac{22}{1+22(0.05\ x\ 0.05)}$$

$$n = 21$$

Taking attrition rate as 20%, the adjusted sample size for the study will be calculated sample size + 20% of sample size ($^{20}/_{100}$ x 21 = 4). Thus, 21 + 4 = 25 to accommodate for attrition rate.

Data Collection Procedure

At presentation, the injured patients were assessed and resuscitated following established principles and guidelines for management of the trauma patient by the investigator. This usually involves initial assessment and resuscitation following the Advanced Trauma Life Support ATLS protocol. Wound inspection/clinical photographs, open fractures were copiously lavaged, dressing with sterile saline soaked gauze, commencement of intravenous broad-spectrum antibiotics, adequate analgesia, anti-tetanus prophylaxis where indicated and splinting of the affected limb(s). Collection of blood samples and urinalysis done. Other investigations such as electrolyte, urea and creatinine, ECG and chest radiograph were done depending on the patients age, comorbid status as well as pre-operative anaesthetic evaluation. Plain radiograph to determine fracture morphology and Doppler ultrasound in selected cases with vascular injury. The investigator participated in the management of the patients from their presentation at the emergency till they were discharged and subsequent follow up at outpatient clinic.

After resuscitation, the patients were evaluated by the investigator. A detailed history was taken, and a thorough physical examination was done with emphasis on injured limb – assessing the extent of soft tissue injury and neurovascular status.

To validate mangled extremity severity score, the decision of either to amputate or salvage a limb was based on the extent of skeletal and soft tissue injury.

It was in consultation with the managing orthopaedic consultant, including the method of skeletal stabilization for those that require salvage procedures who were co-managed with the plastic surgeon. The investigator characterized the severity of the injury at the time of initial presentation and injuries were scored using both MESS and PSI.

The threshold score of 7 for MESS was used in calculating sensitivity, specificity and predictive value for predicting amputation.

Definition of terms

Sensitivity (the probability that limbs requiring an amputation would have limb – salvage score at or above the index threshold) is the number of limbs amputated with MESS

equal or above 7 divided by the total number of limbs amputated multiplied by 100.

Specificity (the probability that salvaged limbs will have limb salvage score below the threshold) is the number of salvaged limbs with MESS scores below 7 divided by the total number of salvaged limbs multiplied by 100.

The *positive predictive value* (PPV), measures the incidence of amputation if amputation is predicted and *negative predictive value* (NPV) which measure the incidence of salvage if salvage is predicted were calculated.

Patient's progress was followed up in the wards by assessment of general wellbeing, soft tissue healing, ambulation (which usually was non-weight bearing with aid of bilateral axillary crutches) until patient was discharged. The wounds were inspected by the investigator at least once every week, assessing the need for second look debridement, looking out for exposure of bone, evidence of infection. Soft tissue was assessed to have healed when fresh scar has formed and there is no need for further wound dressing. Rehabilitation was commenced in the immediate post-operative period. Range of motion exercises for the knee and ankle, calf exercises and non-weight bearing ambulation with bilateral crutches were started with the help of the physiotherapist as soon as pain allowed (according to patients' needs). Patients were discharged when their soft tissue injuries had healed, and they are able to ambulate confidently as instructed (either non-weight bearing or partial weight bearing).

A structured proforma was used to collect data after obtaining an Informed consent. (Appendix l)

The first set of information had to do with the socio-demographic characteristics i.e. age, sex, educational level, occupation, date of presentation and literacy level. The second set of data had to do with the indications for amputation. Third set as regards the clinico-pathological details such as operation date, type of amputation, level of amputation, mode of presentation, interval between presentation and surgery, and level of amputation. The fourth set of data has to do with information related to the outcome of management including clinical outcome (post-operative complications, length of hospital stays and mortality) were collected and entered manually in the proforma.

Data Analysis

Data were analyzed using Statistical Package for Social Sciences (SPSS) version 23.0. Demographic variables were represented using tables and charts. Summary statistics was done using mean, ranges, standard deviation and proportions.

Data interpretation

		The truth		
		Has the disease	Does not have the disease	
Test score	Positive	True Positives (TP) ***a***	False Positives (FP) ***b***	PPV = $\frac{TP}{TP+FP}$
	Negative	False Negatives (FN) ***c***	True Negatives (TN) ***d***	NPV = $\frac{TN}{TN+FN}$
		Sensitivity $\frac{TP}{TP+FN}$	Specificity $\frac{TN}{TN+FP}$	
		Or, $\frac{a}{a+c}$	$\frac{d}{d+b}$	

Results

A total of 25 patients with 27 mangled extremities that met the inclusion criteria were evaluated. One (4%) patient was lost to follow up in the amputation group and one (4%) patient died in the salvage group. 23 Patients with 25 mangled extremities completed 12 weeks of follow up and were used for the study. Most of the participants in the study were males (91%) with age range of 18 – 65 years and a mean age of 32.2years. 16(64%) extremities were salvaged while 9(36%) were amputated.

Table 2: Distribution of mangled extremity and treatment

Treatment	Frequency	Percentage
Amputation	9	36
Salvage	16	64
Total	25	100

Table 3: Mangled extremity severity score and treatment

MESS	Amputation	Salvage	Total
>7	8 (TP)	9 (FP)	17
<7	1 (FN)	7 (TN)	8
Total	9	16	25

Key: TP – True positive, FP – False positive, TN – True Negative, FN – False negative

Twenty-five mangled lower limbs in twenty-three patients with mean MESS of 7.84 ± 2.1 and score range 5 to 12 were studied. Seventeen had a MESS >7 while eight had a score <7. Mangled extremity severity score (MESS) in this study had a sensitivity of 89%,

specificity of 43.8%, positive predictive value of 47.1% and negative predictive value of 87.5%.

Sensitivity = 8/8+1 ×100 = 89%
Specificity = 7/7+9 × 100 = 43.8%

Positive predictive value = 8/8+9 × 100 = 47.1%

Negative predictive value = 7/7+1 × 100 = 87.5%

Table 4: Predictive Salvage Index and Treatment

PSI	Amputation	Salvage	Total
>8	5(TP)	3(FP)	8
<8	4(FN)	13(TN)	17
Total	9	16	25

Key: TP – True positive, FP – False positive, TN – True Negative, FN – False negative

Twenty-five mangled lower limbs in twenty-three patients with the mean PSI of 10.00±1.7 and score range of 7 – 12. Predictive salvage index (PSI) in this study had a sensitivity of 55%, specificity of 81.25%, positive predictive value 62.50% and negative predictive value of 76.47%.

Sensitivity = 5/5+4 × 100 = 55%

Specificity = 13/13+3 ×100 = 81.25%

Positive predictive value = 5/5+3 ×100 = 62.50%

Discussion:

The lower extremity injury severity scores were developed to assist the surgeon in making the initial decision of whether to salvage or amputate an injured limb. In this study 23 patients were enrolled with 25 mangled extremities. Patients age ranged from 18 - 65 with a mean age of 32.2 ± 12.9 year. Most of the patients 19(83%) in this study were in the productive age group between 18 – 30 years followed by those 31-45 years. This age distribution pattern is in keeping with the results of previous studies.[11,12] This may be due to higher incidence of trauma in the third and fourth decades of life.

The sex distribution of the patients shows males were 21(91%) and 2(9%) of the cases were females. There was male preponderance. This may be explained by the fact that the group being the productive age group is commonly involved in activities with higher risk of trauma. Thirteen (52%) injured extremities had reduced pulse but normal perfusion. It may

be due to temporary depression in the blood pressure at the time of presentation to the hospital which could negatively affect the outcome of the patient. Nine (36%) had cold paralysed, insensate limbs, due to prolong warm ischaemic time. MESS assisted in decision making for injuries with vascular component. As the "vascular injury" was not clearly defined, the MESS has been used extensively for the evaluation of limbs with normal vascularity also. It is difficult to obtain a score of 7 and above when the vascularity is intact even though the bone and soft tissue damage is so extensive that salvage is impossible or doomed to fail. As a result, higher rates of limbs underwent failed attempts at salvage and secondary amputations[6].

The sensitivity of MESS in this study was 89% while the specificity was 43.8%. The positive predictive value and negative predictive value were 47.1% and 87.5% respectively. The high sensitivity and low specificity of MESS in this study was similar to what was noted by Rajasekaran *et al*[3] which found that MESS had a poor specificity of 17% and high sensitivity of 99%. Although, this was at variance with findings of Helfet, *et al*[13] which show MESS of high specificity of 100%. Johansen *et al*[6] reported that a score of 7 or more predicted amputations with 100% accuracy. This may be linked to inter-observer difference when calculating MESS score especially when assigning scores to the 3rd and 4th parameters of skeletal and soft tissue injury component of MESS.

Also, the results may not be generalized to other centres. Participants in this study were treated at level-1 trauma centre with well-established orthopaedic trauma programs.

In the decision to amputate high specificity is clearly important to ensure that only a small number of salvageable limbs are incorrectly assigned a score above the decision threshold. Sensitivity is also important, however, to guard against inappropriate delay in amputation when the limb is ultimately not salvageable. High rates of complications including death have been reported in these latter cases.

Predictive salvage index (PSI) sensitivity was 55% while the specificity was 81.25%. The positive predictive value and the negative predictive value were 62.5% and 76 .47% respectively. The high specificity and low sensitivity of PSI in this study was similar to the results recorded by Bosse, *et al*[1]. They found that PSI had sensitivity of 56% and specificity of 79%. Howe, *et al*[9] reported a sensitivity of 78% and a specificity of 100% in their cohort of patients. This finding was at variance with what was noted by Durham *et al*[14] which found high sensitivity of 96%. This difference may be linked to the availability of state-of-the-art equipment for limb salvage.

The PSI scoring variables that were given importance were the extent of vascular injury, the degree of bone damage, the degree of injury to the muscles, and the warm ischemia time.

Some of these variables have no profound effect on outcome of treatment like that of MESS. Arterial injury level in this study was infrapopliteal and the degree of osseous and muscle injuries were moderate to severe with 36% and 64% respectively.

Conclusion:

The result of this study showed that MESS has high sensitivity and low specificity than PSI which had higher specificity and lower

sensitivity than MESS in predicting amputation and limb salvage in patients with mangled lower extremity injuries.

It was therefore recommended that surgeons should use both tools in decision making of limb salvage and amputation for optimal outcome.

References

1. Bosse MJ, Mackenzie EJ, Kellam JF, Burgess et al. A prospective evaluation of the clinical utility of the lower extremity injury – severity scores. *J Bone Joint Surg* (Am) 2001; 83:3 – 14.
2. Wolinsky PR, Webb LX, Harvey EJ, Tejwani NC. The mangled limb: salvage versus amputation. *Instr Course Lect*. 2011; 60:27 – 34.
3. Rajasekaran S. The utility of scores in the decision to salvage or amputation in severely injured limb. *Indian Journal of Orthopaedics* 2008; 42:368 – 376.
4. McNamara MG, Heckman JD, Corloy EG. Severe open fracture of the lower extremity: A retrospective evaluation of the mangled extremity severity score (MESS). *J Orthop Trauma* 1994; 8:81–87.
5. Russel WL, Sailors DM, Whittle TB, *et al*. Limb salvage versus traumatic amputation. A decision based on a seven – part predictive index. *Ann Surg*. 1991; 213:473 – 481.
6. Johansen K, Daines M, Howey T, *et al*. Objective criteria accurately predict amputation following lower extremity trauma. *J Trauma*. 1990; 30:568 – 573.
7. Prasarn ML, Helfet DL, Kloen P. Management of the mangled extremity. *Strat Traum Limb Recon* 2012; 7:57 – 66
8. Lange RH. Limb reconstruction versus amputation decision making in massive lower extremity trauma. *Clin Orthop*. 1989; 243:92 – 9.
9. Howe HR Jr, Poole GV, Hansen KJ, *et al*. Salvage of lower extremities following combined orthopedic and vascular trauma. A predictive salvage index. *AM surg*. 1987; 53:205 – 8.
10. Yamane T. Statistics: An Introductory Analysis, 2nd ed. New York*: Harper and Row*. 1997; 1- 10.
11. Onuminya JE, Ukegbu ND, Onabowale BO. A randomized controlled trial of primary closure for type IIIA open tibial shaft fractures. *Nig Med. Pract*. 1998; 35(1):16 – 18.
12. Ifesanya AO, Alonge TO, Omololu BA, *et al*. Changing trends in the pattern of tibial shaft fractures in Nigeria. A review of 70 cases. *J. Orthop*. 2008; 5(2):231 – 239.
13. Helfet DL, Howey T, Sanders R, *et al*. Limb salvage versus amputation. Preliminary results of the mangled extremity severity score. *Clin Orthop Relat Res*. 1990; 256:80 – 86.
14. Durham RM, Mistry BM, Mazuski JE, *et al*. Outcome and utility of scoring systems in the management of the mangled extremity. *AM J Surg*. 1996; 172:569 – 574.

APPENDIX 1

MANGLED EXTREMITY SEVERITY SCORE (MESS)

PARAMETERS OF SCORING	SCORE
SKELETAL/SOFT TISSUE GROUP	
Low energy Stab, simple fracture, pistol gunshot wounds	1
Medium energy: Open or multiple fracture, dislocation	2
High energy: High speed RTA or rifle GSW	3
Very high energy: High speed trauma plus gross contamination	4
LIMB ISCHAEMIA	
Pulse reduced or absent but perfusion normal	*1
Pullseless, paraesthesia and diminished capillary refill	*2
Cold paralysed, insensate	*3
SHOCK	
Systolic BP always greater than 90mmHg	0
Transient hypotension	1
Persistent hypotension	2
AGE	
< 30years	0
30 – 50 years	1
> 50 years	2

Score is doubled if ischaemia is more than 6hours.If the sum of the scores is greater than or equal to 7, amputation is indicated. If the score is less than 7, successful limb salvage may be indicated.

PREDICTIVE SALVAGE INDEX

Artery	Score
Supra Popliteal level	1
Popliteal level	2
Infra popliteal level	3
Bone	
Mild	1
Moderate	2
Severe	3
Muscle	
Mild	1
Moderate	2
Severe	3
Interval up to operating theatre	
Less than 6hours	1
6-12hours	2
Greater than 12hours	3

If the sum of the scores is greater than or equal to 8, amputation is indicated. If the score is less than 8, successful limb salvage may be indicated.

Cite this Article as: Yakubu Surajuddeen, Abdurrahman Alhaji Mamuda, Bashir Bell. Comparative Evaluation of Diagnostic Accuracy of MESS and PSI in Lower Limb Amputation Following Trauma Presenting at the National Orthopaedic Hospital, Dala Kano. **Bo Med J 2018;16(1): Source of Support:** Nil, **Conflict of Interest:** None declared