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The Relevance of Mangled Extremity Severity Score to Predict Amputation: A Systematic Review

Respati Suryanto Dradjat*, Panji Sananta, Galuh Ayu Ratna Savitri, Alva Pribadi

Department of Orthopaedic and Traumatology, Faculty of Medicine, Universitas Brawijaya, Saiful Anwar General Hospital, Malang, Indonesia

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***Correspondence:** Respati Suryanto Dradjat, Department of Orthopaedic and Traumatology, Faculty of Medicine Universitas Brawijaya, Saiful Anwar General Hospital, Malang, Indonesia.
E-mail: respatisdradjat@ub.ac.id
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Abstract

BACKGROUND: Amputation is one of the most common surgical procedures in the world. One of the criteria for assessing amputation is the mangled extremity severity score (MESS). The MESS criterion has been used for many years, but the accuracy remains unknown. The aim of this study is to know the accuracy of MESS.

METHOD: Keywords of "relevance," "mangled extremity score," and "amputation," and its combination were entered into the PubMed database. Four evaluators reviewed articles from the past 5-year publication date with the English language to select relevant articles.

RESULTS: The outcomes of this systematic review are the sensitivity and specificity of several scoring tools to predict amputation and recommendations for MESS use. The author identified 26 relevant articles with MESS to predict amputation, and most of them recommend using MESS. The sensitivity and specificity of MESS were variable from 63–73% to 70–76%.

CONCLUSION: The MESS performs better in the amputation prediction of the lower extremity arterial injury. Other scoring recommendations are LogisticReg + Nearmiss, ISS, BN, and GHOIS.

Introduction

Amputation is one of the most commonly performed surgical procedures in the world. Amputation is a surgical procedure to remove part or all of the limb organs or the body's protrusion. This procedure aims to save the patient's life, maintain function, or cosmetic reasons [1]. The number of amputation procedures performed globally is 0.7 in every 1000 population, while, in Asia, there are 31 patients out of 1000 population. In the United States, approximately 150,000 patients undergo amputation surgical procedures every year [2]. In 2017, 57.7 million people lived with limb amputation due to traumatic causes worldwide. The most traumatic causes of limb amputation were falls (36.2%), road injuries (15.7%), transportation injuries (11.2%), and other mechanical forces (10.4%) [3]. The amputation rate in Indonesia in 2010–2011 increased from 35.5% to 54.8% [4].

Amputation is the last option in surgical procedures, because it can affect the patient's quality of life. Therefore, an objective consideration needs to be made before choosing this procedure. One of the criteria for assessing amputation determination is the mangled extremity severity score (MESS) [5].

MESS is a criterion for assessing the severity of limb trauma [6]. This criterion assesses the degree of bone and soft-tissue injury, ischemia, presence of shock, patient age, and time of ischemia. Each parameter will be evaluated, and if the score reaches more than seven, it can be considered early amputation [7]. The MESS criterion has been used for a long time, but its reliability is uncertain. Unfortunately, some research shows that MESS cannot be used as an appropriate amputation criterion in their cases [7]. Therefore, this systematic review aims to assess the relevance of using MESS in amputation prediction and find the alternative criteria in considering the amputation.

Methods

A literature review was conducted from 23 to March 25, 2021 using the keywords "relevance," "mangled extremity score," and "amputation," and its

combination in bibliographic databases with restrictions in the English language and human subjects. Four independent evaluators reviewed at abstracts and titles to find papers that fulfilled the study's inclusion criterion. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to perform the comprehensive data collection. After searching with those keywords, the authors used 5 years publication date and English language to select the appropriate journal. Journals were reviewed from title and abstract and followed inclusion and exclusion criteria. The inclusion criteria were an original article, a full-text paper, and using MESS for scoring amputation. The exclusion criteria were case reports, review articles, not using MESS for scoring amputation, and no data analysis.

In this study, there are 158 articles identified, and nine duplicated articles are removed. The remaining 149 articles were evaluated separately by four evaluators using previously used techniques in similar studies. Eighty-eight articles are not research articles, and 13 articles are not written in English, leaving 48 articles for the next screening. After 5 years of publication screening, ten articles are excluded from the study. There are 13 studies excluded consist of: case report (two articles), review article (one article), without MESS scoring (four articles), no data analysis (one article), and do not focus on scoring amputation (four articles). The journal search strategy is showed in Figure 1.

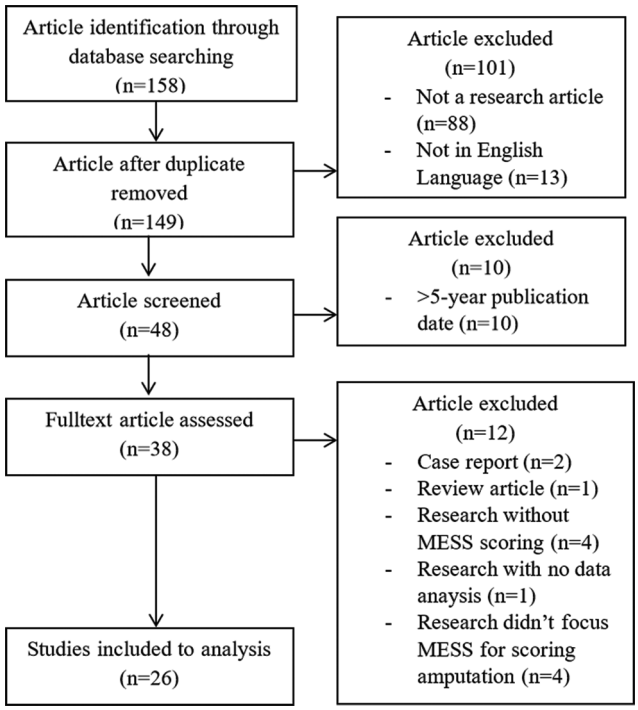

Figure 1: The Preferred Reporting Items for Systematic Reviews and Meta-Analyses flow diagram of the literature selection

The outcomes of this review are the sensitivity and specificity of several scoring tools to predict amputation and the conclusions of the articles on whether or not MESS is recommended as a scoring tool for assessing the severity of limb trauma to predict amputation. The quality of included studies was critically appraised using CEBM Harm/Etiology/Risk Critical Appraisal Worksheet and Oxford Center for Evidence-Based Medicine 2011 Levels of Evidence. Excel spreadsheets were used to extract and process all data acquired from all reviewed studies.

Results

The initial PubMed search yielded 158 titles with 38 full-text articles assessed according to the inclusion and exclusion criteria. Twelve of the 38 articles had a study design that matched the criteria of this study but were not included in this review article, because they included case reports, did not address MESS specifically, and did not have data analysis. Therefore, those articles were eliminated, and the final number of articles analyzed was 26 articles.

Based on Table 1, most of the cases from this journal are lower extremity arterial injuries. All studies use the retrospective cohort method, and the total number of patients is 5419 samples. The largest number of samples is owned by a study by Polcz *et al.*, 2020, which has 691 patients with the lower extremity arterial injury.

Table 1: Characteristics of the studies

Author	Σ sample	Design	Case
Bolourani *et al.*, 2021 [8]	1098	Retrospective	Lower extremity arterial injury
Cho *et al.*, 2020 [9]	28	Retrospective	Upper and lower artery injury
Polcz *et al.*, 2021 [10]	691	Retrospective	Lower extremity arterial injury
Schechtman *et al.*, 2021 [11]	439	Retrospective	Lower extremity arterial injury
Asensio *et al.*, 2020 [12]	76	Retrospective	Popliteal artery injuries
Perkins *et al.*, 2020 [13]	559	Retrospective	Lower extremity arterial injury
Gupta *et al.*, 2020 [14]	219	Retrospective	IIIB open tibia fractures
Hohenberger *et al.*, 2020 [15]	14	Retrospective	Upper extremity traumas
Hohenberger *et al.*, 2020 [16]	71	Retrospective	Trauma with vascular injury
Kauvar *et al.*, 2020 [17]	257	Retrospective	Femoropopliteal arterial injury
Hasde *et al.*, 2019 [18]	96	Retrospective	Lower extremity arterial injury
Ray *et al.*, 2019 [19]	108	Retrospective	Lower extremity arterial injury
Kim *et al.*, 2019 [20]	24	Retrospective	Femoropopliteal arterial injury
Sharrock *et al.*, 2019 [21]	568	Retrospective	Lower extremity arterial injury
Wlodarczyk *et al.*, 2018 [22]	291	Retrospective	Upper and lower extremity Artery injury
Kauvar *et al.*, 2018 [23]	455	Retrospective	Lower extremity arterial injury
Karakus *et al.*, 2017 [24]	600	Retrospective	Upper and lower fracture
Venkatadass *et al.*, 2017 [25]	52	Retrospective	IIIB open tibial and femur fracture
Barla *et al.*, 2017 [26]	20	Retrospective	Femur, tibia, or tibial pilon fracture
Song *et al.*, 2017 [27]	35	Retrospective	IIIC lower extremity trauma
Loja *et al.*, 2017 [7]	230	Retrospective	Lower extremity arterial injury
Liang *et al.*, 2016 [28]	149	Retrospective	Lower extremity arterial injury
Yeh *et al.*, 2016 [29]	242	Retrospective	Lower extremity fracture
Fochtmann *et al.*, 2016 [30]	54	Retrospective	Open fracture upper extremity
Sisli *et al.*, 2016 [31]	90	Retrospective	Upper and lower extremity injury
Keeley *et al.*, 2016 [32]	51	Retrospective	Popliteal vascular injuries

Based on Table 2, it is known that from 26 studies, 15 studies recommend the use of MESS for amputation prediction, and 11 studies do not recommend MESS for amputation prediction. Seven out of nine journals recommend using MESS to predict amputation in cases of lower extremity arterial injury.

On the contrary, it is not recommended to use MESS to score IIIB open tibial fracture cases.

Table 2: Summary MESS Research for Predict Amputation

Author	Case	MESS recommendation for Predict Amputation
Bolourani *et al*., 2021 [8]	Lower extremity arterial injury	Not recommended
Cho *et al*., 2020 [9]	Upper and lower artery injury	Recommended
Polcz *et al*., 2021 [10]	Lower extremity arterial injury	Recommended
Schechtman *et al*., 2021 [11]	Lower extremity arterial injury	Recommended
Asensio *et al*., 2020 [12]	Popliteal artery injuries	Not recommended
Perkins *et al*., 2020 [13]	Lower extremity arterial injury	Not recommended
Gupta *et al*., 2020 [14]	IIIB open tibia fractures	Not recommended
Hohenberger *et al*., 2020 [15]	Upper extremity traumas	Not recommended
Hohenberger *et al*., 2020 [16]	Trauma with vascular injury	Not recommended
Kauvar *et al*., 2020 [17]	Femoropopliteal arterial injury	Recommended
Hasde *et al*., 2019 [18]	Lower extremity arterial injury	Not recommended
Ray *et al*., 2019 [19]	Lower extremity arterial injury	Recommended
Kim *et al*., 2019 [20]	Femoropopliteal arterial injury	Recommended
Sharrock *et al*., 2019 [21]	Lower extremity arterial injury	Recommended
Wlodarczyk *et al*., 2018 [22]	Upper and lower extremity artery injury	Recommended
Kauvar *et al*., 2018 [23]	Lower extremity arterial injury	Recommended
Karakus *et al*., 2017 [24]	Upper and lower fracture	Recommended
Venkatadass *et al*., 2017 [25]	IIIB open tibial and femur fracture	Not recommended
Barla *et al*., 2017 [26]	Femur, tibia, or tibial pilon fracture	Recommended
Song *et al*., 2017 [27]	IIIC lower extremity trauma	Recommended
Loja *et al*., 2017 [7]	Lower extremity arterial injury	Not recommended
Liang *et al*., 2016 [28]	Lower extremity arterial injury.	Recommended
Yeh *et al*., 2016 [29]	Lower extremity fracture	Not recommended
Fochtmann *et al*., 2016 [30]	Open fracture upper extremity	Not recommended
Sisli *et al*., 2016 [31]	Upper and lower extremity injury	Recommended
Keeley *et al*., 2016 [32]	Popliteal vascular injuries	Recommended

MESS: Mangled extremity severity score

Based on Table 3, five types of scoring are recommended: MESS, Logistic Reg + Nearmiss, ISS, BN, and GHOIS. The score that has the highest sensitivity and specificity is the GHOIS. The scoring with the lowest sensitivity and specificity was MESS. However, most researchers still recommend MESS for amputation prediction.

Table 3: Sensitivity and specificity of MESS and other amputation scores

Author	Scoring recommendation	Sensitivity	Specificity
Bolourani *et al*., 2021 [8]	LogisticReg + Nearmiss	71	75
Cho *et al*., 2020 [9]	MESS	63	76
Polcz *et al*., 2021 [10]	MESS	-	-
Schechtman *et al*., 2021 [11]	MESS	-	-
Asensio *et al*., 2020 [12]	ISS	-	-
Perkins *et al*., 2020 [13]	BN	94.6	85
Gupta *et al*., 2020 [14]	GHOIS	100	90
Hohenberger *et al*., 2020 [15]	-	-	-
Hohenberger *et al*., 2020 [16]	-	-	-
Kauvar *et al*., 2020 [17]	MESS	-	-
Hasde *et al*., 2019 [18]	-	-	-
Ray *et al*., 2019 [19]	MESS	73	70
Kim *et al*., 2019 [20]	MESS	-	-
Sharrock *et al*., 2019 [21]	MESS	-	-
Wlodarczyk *et al*., 2018 [22]	MESS	-	-
Kauvar *et al*., 2018 [23]	MESS	-	-
Karakus *et al*., 2017 [24]	MESS	-	-
Venkatadass *et al*., 2017 [25]	GHOIS	75	93.75
Barla *et al*., 2017 [26]	MESS	-	-
Song *et al*., 2017 [27]	MESS	-	-
Loja *et al*., 2017 [7]	-	-	-
Liang *et al*., 2016 [28]	MESS	-	-
Yeh *et al*., 2016 [29]	ISS	-	-
Fochtmann *et al*., 2016 [30]	-	-	-
Sisli *et al*., 2016 [31]	MESS	-	-
Keeley *et al*., 2016 [32]	MESS	-	-

MESS: Mangled extremity severity score

The risk of bias in this study is that not every article mentions the recommended scoring tool's sensitivity and specificity, and not all articles explicitly recommend a specific scoring tool to be used. Drawing conclusions and recommendations are not easy due to different methodologies, cases, and heterogeneous patient characteristics. Despite the aforementioned drawbacks, some valuable observations can be made with the available data.

Discussion

Twenty-six studies related to MESS are analyzed, and 15 studies recommend the use of MESS to predict amputation. A total score of more than seven points in MESS can provide amputation prediction in most research. Venkatadass *et al.* and Gupta *et al.* do not recommend MESS as a prediction tool for amputation in open tibial fracture [14], [25]. Other research by Fochtmann *et al.* shows that MESS cannot predict amputation in open fracture at the upper extremity [30]. In the lower extremity arterial injury cases, most of the research suggests MESS to predict amputation. MESS has a sensitivity 63% and specificity 76% to predict amputation surgery in the lower extremity arterial injury [9], and it reported 73% and 70%, respectively, in Ray *et al.* study [19]. The prevalence of diseases influences the sensitivity and specificity variation of MESS.

In this systematic review, 11 studies do not recommend MESS for amputation prediction. Three articles show that MESS does not significantly predict amputation, and one article prefers temporary intravascular shunt (TVS) as a preliminary treatment between the initial injury and definitive therapy that reduces amputation rates. Other six articles prefer Logistic Reg + Nearmiss, ISS, BN, and GHOIS, because MESS has lower sensitivity and specificity. LogisticReg + Nearmiss is a scoring developed by Bolourani *et al.*, which has a sensitivity of 71% and a specificity of 75% from 1098 patients study analyzed by linear regression. ISS is a multiple injury scoring system with unknown sensitivity and specificity, in which each injury is assigned an abbreviated injury scale score and is used to one of six body regions [33]. Tohira *et al.* show that ISS also has low sensitivity and specificity to predict mortality in blunt injury; therefore, the new modification of ISS (NISS) might perform better [34]. BN has a sensitivity of 94.6% and a specificity of 85% to predict amputation in lower extremity arterial injury [13], but other studies state that scoring system cannot be used as prediction tools in clinical utility [35]. GHOIS is a simple scoring system developed for doctors to grade the severity of tibia fractures. The total score can be used to decide limb salvage or amputation [36]. Research by Shanmuganathan *et al.* shows that GHOIS can be predicting amputation for IIIB injury patients. GHOIS consists of some items such as skin loss, skeletal structure, functional tissue (musculotendinous and nerve), and comorbidity [37].

This study has several limitations, including all of this research uses recent 5 years of publication, and some of the studies presented do not show the

distribution of cases that allowing a large variety of cases and causing bias. Besides, no study compares MESS with the other four scores, so it is difficult to compare the sensitivity and specificity.

Conclusion

The MESS may perform better in the amputation prediction of the lower extremity arterial injury. The other recommended scoring systems are LogisticReg + Nearmiss, ISS, BN, and GHOIS. GHOIS has the highest sensitivity and specificity, but the research is still limited. Additional studies are required to compare MESS and other scoring systems' sensitivity and specificity in the same research.

References

1. Schnur D, Meier RH 3rd. Amputation surgery. Phys Med Rehabil Clin N Am. 2014;25(1):35-43. https://doi.org/10.1016/j.pmr.2013.09.013
   PMid:24287238
2. Dillingham TR, Pezzin LE, Shore AD. Reamputation, mortality, and health care costs among persons with dysvascular lower-limb amputations. Arch Phys Med Rehabil. 2005;86(3):480-6. https://doi.org/10.1016/j.apmr.2004.06.072
   PMid:15759232
3. McDonald CL, Westcott-McCoy S, Weaver MR, Haagsma J, Kartin D. Global prevalence of traumatic non-fatal limb amputation. Prosthet Orthot Int. 2021;45(2):105-14. https://doi.org/10.1177/0309364620972258
   PMid:33274665
4. Purwanti LE. The relationship between motivation and self-efficacy of Type 2 DM patients in performing foot care in the work area of North Ponorogo Public Health Center. Gaster. 2014;11(2):68-77.
5. Fagelman MF, Epps HR, Rang M. Mangled extremity severity score in children. J Pediatr Orthop. 2002;22(2):182-4.
   PMid:11856926
6. Johansen K, Hansen ST Jr. MESS (Mangled extremity severity score) 25 years on: Time for a reboot? J Trauma Acute Care Surg. 2015;79(3):495-6. https://doi.org/10.1097/TA.0000000000000767
   PMid:26307887
7. Loja MN, Sammann A, DuBose J, Li CS, Liu Y, Savage S, *et al*. The mangled extremity score and amputation: Time for a revision. J Trauma Acute Care Surg. 2017;82(3):518-23. https://doi.org/10.1097/TA.0000000000001339
   PMid:28030489
8. Bolourani S, Thompson D, Siskind S, Kalyon BD, Patel VM, Mussa FF. Cleaning up the MESS: Can machine learning be used to predict lower extremity amputation after trauma-associated arterial injury? J Am Coll Surg. 2021;232(1):102-13.e4. https://doi.org/10.1016/j.jamcollsurg.2020.09.014
   PMid:33022402
9. Cho H, Huh U, Lee CW, Song S, Kim SH, Chung SW. Traumatic peripheral arterial injury with open repair: A 10-year single-institutional analysis. Korean J Thorac Cardiovasc Surg. 2020;53(5):291-6. https://doi.org/10.5090/kjtcs.19.087
   PMid:33020347
10. Polcz JE, White JM, Ronaldi AE, Dubose JJ, Grey S, Bell D, *et al*. Temporary intravascular shunt use improves early limb salvage after extremity vascular injury. J Vasc Surg. 2021;73(4):1304-13. https://doi.org/10.1016/j.jvs.2020.08.137
    PMid:32987146
11. Schechtman DW, Walters TJ, Kauvar DS. Utility of the mangled extremity severity score in predicting amputation in military lower extremity arterial injury. Ann Vasc Surg. 2021;70:95-100. https://doi.org/10.1016/j.avsg.2020.08.095
    PMid:32866576
12. Asensio JA, Dabestani PJ, Miljkovic SS, Kotaru TR, Kessler JJ, Kalamchi LD, *et al*. Popliteal artery injuries. Less ischemic time may lead to improved outcomes. Injury. 51(11):2524-31. https://doi.org/10.1016/j.injury.2020.07.046
    PMid:32732120
13. Perkins ZB, Yet B, Sharrock A, Rickard R, Marsh W, Rasmussen TE, *et al*. Predicting the outcome of limb revascularization in patients with lower-extremity arterial trauma: Development and external validation of a supervised machine-learning algorithm to support surgical decisions. Ann Surg. 2020;272(4):564-72. https://doi.org/10.1097/SLA.0000000000004132
    PMid:32657917
14. Gupta A, Parikh S, Rajasekaran RB, Dheenadhayalan J, Devendra A, Rajasekaran S. Comparing the performance of different open injury scores in predicting salvage and amputation in Type IIIB open tibia fractures. Int Orthop. 2020;44(9):1797-804. https://doi.org/10.1007/s00264-020-04538-5
    PMid:32328740
15. Hohenberger GM, Cambiaso-Daniel J, Schwarz AM, Boukovalas S, Seibert FJ, Konstantiniuk P, *et al*. Traumatic upper extremity injuries: Analysis of correlation of mangled extremity severity score and disabilities of the arm, shoulder and hand score. Ulus Travma Acil Cerrahi Derg. 2020;26(1):95-102. https://doi.org/10.14744/tjtes.2019.44939
    PMid:31942737
16. Hohenberger GM, Konstantiniuk P, Cambiaso-Daniel J, Matzi V, Schwarz AM, Lumenta DB, *et al*. The mangled extremity severity score fails to be a good predictor for secondary limb amputation after trauma with vascular injury in central Europe. World J Surg. 2020;44(3):773-9. https://doi.org/10.1007/s00268-019-05263-w
    PMid:31686160
17. Kauvar DS, Propper BW, Arthurs ZM, Causey MW, Walters TJ. Impact of staged vascular management on limb outcomes in wartime femoropopliteal arterial injury. Ann Vasc Surg. 2020;62:119-27. https://doi.org/10.1016/j.avsg.2019.08.072
    PMid:31476424
18. Hasde Aİ, Baran Ç, Gümüş F, Kış M, Özçınar E, Çakıcı M, *et al*. Effect of temporary vascular shunting as a previous intervention on lower extremity arterial injury: Single center experiences in the Syrian Civil War. Ulus Travma Acil Cerrahi Derg. 2019;25(4):389-95.
19. Ray HM, Sandhu HK, Meyer DE, Miller CC, Vowels TJ, Afifi RO, *et al*. Predictors of poor outcome in infrainguinal bypass for trauma. J Vasc Surg. 2019;70(6):1816-22. https://doi.org/10.1016/j.jvs.2019.03.056
    PMid:31248764
20. Kim JH, Jeon YS, Cho SG, Hong KC, Park KM. Risk factors of amputation in lower extremity trauma with combined femoropopliteal arterial injury. Vasc Spec Int. 2019;35(1):16-21.

https://doi.org/10.5758/vsi.2019.35.1.16

PMid:30993103

21. Sharrock AE, Tai N, Perkins Z, White JM, Remick KN, Rickard RF, *et al*. Management and outcome of 597 wartime penetrating lower extremity arterial injuries from an international military cohort. J Vasc Surg. 2019;70(1):224-32. https://doi.org/10.1016/j.jvs.2018.11.024

PMid:30786987

22. Wlodarczyk JR, Thomas AS, Schroll R, Campion EM, Croyle C, Menaker J, *et al*. To shunt or not to shunt in combined orthopedic and vascular extremity trauma. J Trauma Acute Care Surg. 2018;85(6):1038-42. https://doi.org/10.1097/TA.0000000000002065

PMid:30211849

23. Kauvar DS, Miller D, Walters TJ. Tourniquet use is not associated with limb loss following military lower extremity arterial trauma. J Trauma Acute Care Surg. 2018;85(3):495-9. https://doi.org/10.1097/TA.0000000000002016

PMid:30020226

24. Karakus A, Kuvandik G, Atalay E. Evaluation of extremity injuries presented to emergency department. Arch Iran Med. 2017;20(10):646-8.

PMid:29137466

25. Venkatadass K, Grandhi TS, Rajasekaran S. Use of ganga hospital open injury severity scoring for determination of salvage versus amputation in open type IIIB injuries of lower limbs in children-An analysis of 52 Type IIIB open fractures. Injury. 2017;48(11):2509-14. https://doi.org/10.1016/j.injury.2017.09.010

PMid:28918873

26. Barla M, Gavanier B, Mangin M, Parot J, Bauer C, Mainard D. Is amputation avaiable treatment option in lower extremity trauma? Orthop Traumatol Surg Res. 2017;103(6):971-5. https://doi.org/10.1016/j.otsr.2017.05.022

PMid:28712989

27. Song W, Zhou D, Dong J. Predictors of secondary amputation in patients with grade IIIC lower limb injuries. Medicine (Baltimore). 2017;96(22):e7068. https://doi.org/10.1097/MD.0000000000007068

Pmid:28562573

28. Liang NL, Alarcon LH, Jeyabalan G, Avgerinos ED, Makaroun MS, Chaer RA. Contemporary outcomes of civilian lower extremity arterial trauma. J Vasc Surg. 2016;64(3):731-6. https://doi.org/10.1016/j.jvs.2016.04.052

PMid:27444360

29. Yeh HK, Fang F, Lin YT, Lin CH, Lin CH, Hsu CC. The effect of systemic injury score on the decision making of mangled lower extremities. Injury. 2016;47(10):2127-30. https://doi.org/10.1016/j.injury.2016.05.023

PMid:27375013

30. Fochtmann A, Binder H, Rettl G, Starlinger J, Aszmann O, Sarahrudi K, *et al*. Third degree open fractures and traumatic sub-/total amputations of the upper extremity: Outcome and relevance of the mangled extremity severity score. Orthop Traumatol Surg Res. 2016;102(6):785-90. https://doi.org/10.1016/j.otsr.2016.04.004

PMid:27209033

31. Şişli E, Kavala AA, Mavi M, Sarıosmanoğlu ON, Oto Ö. Single centre experience of combat-related vascular injury in victims of Syrian conflict: Retrospective evaluation of risk factors associated with amputation. Injury. 2016;47(9):1945-50. https://doi.org/10.1016/j.injury.2016.03.030

PMid:27060019

32. Keeley J, Koopmann M, Yan H, DeVirgilio C, Putnam B, Y. Kim D, *et al*. Factors associated with amputation after popliteal vascular injuries. Ann Vasc Surg. 2016;33:83-7. https://doi.org/10.1016/j.avsg.02.004

PMid:26996406

33. Javali RH, Krishnamoorthy, Patil A, Srinivasarangan M, Suraj, Sriharsha. Comparison of injury severity score, new injury severity score, revised trauma score and trauma and injury severity score for mortality prediction in elderly trauma patients. Indian J Crit Care Med. 2019;23(2):73-7. https://doi.org10.5005/jp-journals-10071-23120

PMid:31086450

34. Tohira H, Jacobs I, Mountain D, Gibson N, Yeo A. Systematic review of predictive performance of injury severity scoring tools. Scand J Trauma Resusc Emerg Med. 2012;20(1):63. https://doi.org/10.1186/1757-7241-20-63

PMid:22964071

35. Assel M, Sjoberg DD, Vickers AJ. The Brier score does not evaluate the clinical utility of diagnostic tests or prediction models. Diagnostic Progn Res. 2017;1(1):19. https://doi.org/10.1186/s41512-017-0020-3

PMid:31093548

36. Rajasekaran S, Sabapathy SR, Dheenadhayalan J, Sundararajan SR, Venkatramani H, Devendra A, *et al*. Ganga hospital open injury score in management of open injuries. Eur J Trauma Emerg Surg. 2015;41(1):3-15. https://doi.org/10.1007/s00068-014-0465-9

PMid:26038161

37. Rajasekharan S. The utility of scores in the decision to salvage or amputation in severely injured limbs. Indian J Orthop. 2008;42(4):368-76. https://doi.org/10.4103/0019-5413.43371

PMid:19753223