Int J Burn Trauma 2021;11(1):34-40
www.IJBT.org /ISSN:2160-2026/IJBT0123876

Original Article

Evaluation the accuracy and cost effectiveness of using the Bernese and Ottawa rules in ankle Sprain

Seyyed Mahdi Zia Ziabari[1], Vahid Monsef[2], Payman Asadi[2], Seyed Mohammad Ghodsi Khorsand[2], Enayatollah Homaie Rad[2], Amir Noyani[3], Saeid Sadeghi Joni[4]

[1]Department of Emergency Medicine, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran; [2]Guilan Road Trauma Research Center, School of Medicine, Guilan University of Medical Sciences, Rasht, Iran; [3]School of Clinical Research Development Unit, Imam Hossein Hospital, Shahroud University of Medical Sciences, Shahroud, Iran; [4]Department of Radiology, Razi Hospital, Guilan University of Medical Sciences, Rasht, Iran

Received October 10, 2020; Accepted December 25, 2020; Epub February 15, 2021; Published February 28, 2021

Abstract: Introduction: Ankle sprain is one of the most common musculoskeletal injuries that occur most commonly in the active and working population. Ottawa and Burns Laws are tools for physicians to determine the need for a radiograph of an ankle injury. The purpose of this study was to evaluate the accuracy of the Ottawa and Bernese criteria in patients with torsion of the foot and the economical savings resulting from the application of these two criteria. Methods: This prospective study was designed to evaluate the two rules burns of Bernese and Ottawa and their economic savings were designed in two phases. They were referred to Poursina Medical Center, Rasht, Iran from September 2019 to the achieved sample size. Data were analyzed by SPSS software version 24 (Statistical Package for Social Science (SPSS) 21, Chicago, IL, USA). Results: A total of 800 patients were included in this study to determine the accuracy of bronze and Ottawa criteria in ankle torsion and the economic cost of using them. Of the 800 patients studied, 430 (53.7%) were male and 370 (46.3%) were female, with a mean age of 35.77±16.42 years. The diagnostic accuracy of the Ottawa criteria is 90% and the diagnostic accuracy of the Bernese criteria is 90.75%. The sensitivity of the Ottawa evaluation method was 97.6% and the specificity was 88%. The sensitivity of Bernese evaluation method was 91% and specificity was 90.7%. Conclusion: Because of the higher sensitivity of the Ottawa criterion than the Bernese criteria, it is preferred to determine the probability of fracture for emergency unit personnel. Using these two methods can reduce the time, energy and cost of treatment for the patient during the treatment period.

Keywords: Emergency department, ankle injury, Otawa ankle rule, Bernese ankle rule, management

Introduction

Ankle sprains are one the most common musculoskeletal injuries [1] with the highest frequency in the active and working population [2], and include mild injuries to the rupture of one or multiple ligaments [3]. Ankle sprains constitute 40% of sports injuries, 25% of musculoskeletal injuries, and 5% of emergency department admissions [4, 5].

Typically, damage to both of these ligaments is caused by the simultaneous inversion and plantar flexion. Eversion can damage the deltoid ligament, but this mechanism of injury is unlikely. Although a few of these patients (15%) have fractures, almost all the patients who have pain undergo x-ray studies [6]. Around the world, there is about one ankle sprain per 10,000 people every day, costing almost $ 2 billion a year in the United States.

Plain radiography of the ankle is the second common imaging in the emergency department. More than five million radiographs are performed at the cost of 500 million dollars annually in the US [7].

Accordingly, various treatment methods have been proposed, including surgery, elastic bandages, taping, semi-rigid supports, lace-up supports, and casting. But the important issue is the patient's need for radiological studies. Evidence indicated that x-ray imaging is not

necessary for patients with no fractures and therefore, using special techniques to avoid unnecessary imaging seems critical [8].

The Ottawa and the Bernese rules are tools for physicians to determine the need for radiography in ankle injuries [9]. The Ottawa ankle rules (OAR) are clinical decision guidelines used to identify whether patients with ankle injuries need to undergo radiography. The OAR has been proven that their application reduces unnecessary radiography. The OAR enhances a physician's efficiency; in the standard, a fracture is defined as bone tenderness and the lack of ability to bear weight [10]. The Ottawa rule is a way to identify the need for radiologic evaluation of the ankle, or in other words, the possibility of a fracture. The standard has a high sensitivity (100%) and a moderate specificity [11].

Using the OAR has decreased the costs and unnecessary radiography [12, 13]. One of the reasons for applying the standard was ruling out a fracture without using X-ray in order to save time and provide cost-benefit proper services [14], and the resultant reduction in hospital unnecessary stay [15].

There is, an indirect malleolar stress test, known as Bernese ankle rules (BARs), that has been proposed by Eggli and colleagues which assesses the ankle injuries [16]. Using this test, physicians would be able to determine if the patient requires an X-ray.

The sensitivity of a method is defined as the correct diagnosis of unhealthy individuals and those who have a fracture in our study, and specificity is defined as the ratio of healthy individuals excluded correctly by rules. As depicted in the present study, the Ottawa rules had a higher sensitivity than the Bernese criterion, while the Bernese criterion had a higher specificity than the Ottawa rules. Besides, the positive predictive value was higher in the Ottawa rules, while the negative predictive value was higher in the Bernese criterion. The results were consistent with similar studies comparing the sensitivity and specificity of the two standards in predicting the severity of ankle fractures [12, 17].

Here in the present study, regarding the high prevalence and importance of ankle sprain and the importance of avoiding unnecessary X-ray imaging, we aimed to compare the beneficial effects and cost-effectiveness of OAR and BAR in patients with ankle injuries. Here for the first time, we aimed to investigate and evaluate the cost-effectiveness of each of the two indexes and compare them. We believe that these indexes could help to significantly reduce medical costs.

Methods and material

Study design

This is a cross-sectional and analytical study that was performed in 2020 in Guilan, Iran on patients with a traumatic ankle injury. The study protocol was approved by the Research Committee of Guilan University of Medical Sciences and the Ethics committee has confirmed it (Ethics code: IR.GUMS.REC.1398.50). The current study was performed on eligible patients referring to the Guilan Road Trauma Research Center in 2019 (June 2019 to March 2020).

Study population

The study population consisted of all patients with traumatic ankle sprain referring to the Guilan Road Trauma Research Center. The method of collecting samples was the census. The inclusion criteria were: age of 18-80 years, ankle injury following a trauma within the past ten days, attendance to Accident and Emergency departments of all educational centers in Guilan, being visited by the emergency medicine residents, having both filled OAR and BAR and signing the written informed consent to participate in this study. The exclusion criteria were: patients with unstable vital signs, and impaired or loss of consciousness and the patient's refusal to participate in the study. Total number of 804 patients were included and 4 patients excluded based on inclusion and exclusion criteria.

Measuring tools

The demographic data of all patients were obtained. Results of OAR and BAR along with results of ankle X-ray were reviewed by two expert emergency specialists and two Orthopedics and the effectiveness, sensitivity, specificity and diagnostic accuracy of these two methods were calculated in patients with frac-

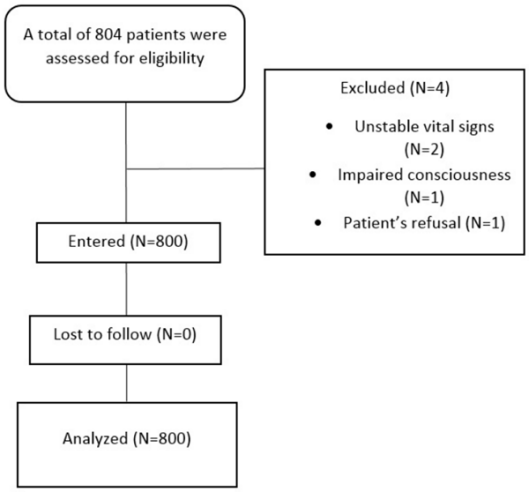

Figure 1. CONSORT flow diagram of the study.

tures in X-ray. We should note that all of the radiographs in our medical center are reported first by expert radiologists for the presence of any fractures and were then examined and confirmed by orthopedics.

Statistical analysis

The data were analyzed by SPSS version 24. The demographic data were analyzed using descriptive statistics (mean and percentage). The classified variables were analyzed by the Chi-squared test. The McNemar's test was used in paired samples to examine the significant difference between the Ottawa and the Bernese rules. Moreover, Spearman's rank correlation coefficient was used to assess the significant relationship between the Ottawa and the Bernese rules and the radiographic images. Significant clinical fractures were identified by calculating the receiver operating characteristic (ROC) curve's sensitivity and specificity. Positive and negative likelihood ratio (LR) and the positive and negative predictive values were calculated. Finally, the cost-effectiveness of using the Ottawa and the Bernese standards were calculated. The statistical significance of this study was 95% confidence interval and *P*-value < 0.05 was considered as the significant threshold.

Results

Population

A total of 804 patients were included. Four patients were excluded for the following reasons: unstable vital signs (n-2), impaired consciousness (n-1) and patient's refusal (n-1). The CONSORT diagram of patients is indicated in **Figure 1**.

Demographic data and sprain characteristics

Of the 800 analyzed cases, 430 were male, and 370 were female and the mean age of patients was 35.77±16.42 years. Our data showed that the most common mechanism of trauma was inversion ankle sprain (58.1%). Eversion was also responsible for 23% of sprains. Most patients complained of pain in the ankle joint (50.5%) and 41.6% of patients had pain in the ankle and foot. These data are summarized in **Table 1**.

Evaluation of OAR and BAR

A total number of 166 patients (21%) had radiographic evidence of fracture, and most of the fractures were observed in the lateral malleolus (15.4% of all cases). We also showed that 283 patients were positive for the OAR and 210 were positive for the BAR (**Table 2**).

Comparison of sensitivity and specificity

Our data also showed that the OAR had higher sensitivity (97.6%) than the BAR (91%); however, the BAR had higher specificity (90.7%) compared to OAR (88%). A comparison of diagnostic accuracy demonstrated that BAR had higher accuracy (90.75%) than OAR (90%). Based on the results of ROC curve, the sensitivity of the Ottawa evaluation method was 97.6% and the specificity was 88%. Also, the positive predictive value was 68.1% and the negative predictive value was 99.3%. In the sensitivity and specificity of the BAR method in the studied patients, it was found that the sensitivity of the BAR evaluation method was 91% and the specificity was 90.7%. Also, the positive predictive value was 71.9% and the negative predictive value was 97.5% (**Figure 2**).

Cost-effectiveness of the two criteria

A total number of 2454 (100%) x-ray images were taken, which could be decreased to 1630 (33.6%) in the case of using both the OAR and BAR. We also calculated the imaging costs: 1.36$ for patients with health insurance and 2.16$ for patients without health insurance (**Table 3**).

Table 1. Comparison of demographic data and sprain characteristics

Variable		Total
Mean age (years (mean ± SD))		35.77±16.42
Gender (N (%))	Male	430 (53.7%)
	Female	370 (46.3%)
Mechanism of trauma (N (%))	Direct force	84 (10.5%)
	Fall	66 (8.3%)
	Inversion	456 (58.1%)
	Eversion	184 (23.1%)
Pain location (N (%))	Unilateral ankle	404 (50.5%)
	Bilateral ankle	47 (5.9%)
	Unilateral ankle and foot	333 (41.6%)
	Bilateral ankle and feet	16 (2%)

Table 2. Evaluation of OAR and BAR in patients

Variable		N (%)
Ottawa standard	Positive	283 (29.8%)
	Negative	562 (70.2%)
Bernese criterion	Positive	210 (26.3%)
	Negative	590 (73.8%)
Fracture in the radiography	Fracture	166 (21%)
	Normal	634 (79%)
False negatives	Ottawa	4 (21%)
	Bernese	15 (1.9%)
False positives	Ottawa	76 (9.5%)
	Bernese	59 (7.4%)
Fracture location	Internal malleolus	52 (6.5%)
	Metatarsus	16 (2%)
	Lateral malleolus	123 (15.4%)
	Navicular	2 (0.3%)
	Calcaneus	6 (0.8%)

Discussion

In the present study, the sensitivity and specificity of the Bernese criterion in the patients was 91% and 90.7%, respectively, which were higher than in the study of Becren and others with a sensitivity of 56% and the specificity of 79% [18]. In the study of Derksen and colleagues, the sensitivity and specificity of the Bernese criterion was 69% and 45% for the emergency medicine residents, and 85% and 40% for the triage nurses, respectively. Moreover, the sensitivity and specificity of the Ottawa rules was 97.6% and 88%, which was higher than in the study of Derksen and colleagues with a sensitivity and specificity of 97% and 29% for the emergency medicine residents, and 86% and 25% for the triage nurses [17]. These could be due to the examiner's experience, sensitivity in determining the pain location, and the evaluation of the pain and injury. The larger sample size in our study could also be contributing to the difference [17].

In a review article by Beckman and others, they reported a higher sensitivity and a lower specificity for the Ottawa rules, with 98.2-100% for sensitivity and 26.3-47.9%, for specificity [19]. On the other hand, the larger sample size of this study compared with others could contribute to the reliability of the sensitivity and specificity obtained for the two criteria [3, 20].

In the study of Couz and others, they reported a higher sensitivity (100%) and a lower specificity (77%) of the Ottawa criteria compared with those of ours. Factors such as sex differences, sample size, the experience of the resident, nurse, or the professors, different race of patients, patient's prior experience, and different cultural and personal factors of the patients could be affecting the results of the standards and thus, justify the differences in the sensitivity and specificity of the Ottawa and the Bernese standards in different studies.

The higher specificity of a method means the higher accuracy of the method and reduces unnecessary x-ray studies and prevents the waste of time and cost for the patients. The methods are more reliable as their specificity reaches 100% [19, 20]. In the present study, the Bernese criterion had a higher specificity than the Ottawa rules, which was consistent with the results of Derksen and others [17].

In our study, an AP and lateral image were requested if the pain was limited to the ankle joint, and an AP, lateral image of the ankle joint,

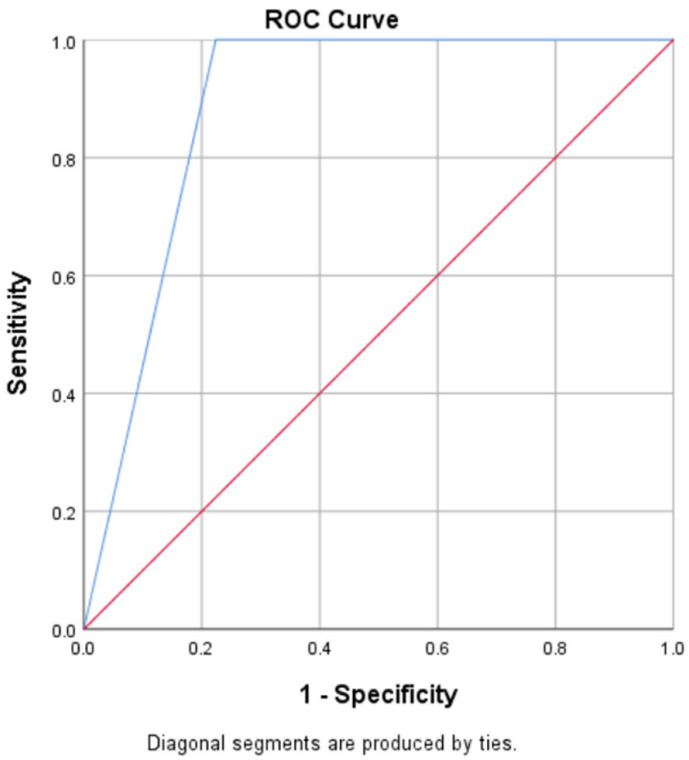

Figure 2. ROC curve evaluating the specificity and sensitivity of both methods.

and an AP and oblique image of the foot was requested in case of pain in ankle joint and foot. If the trauma was bilateral, bilateral imaging was requested. The patients' out of pocket costs were also calculated; the cost of each radiograph in a public hospital was 1.36$ for patients with health insurance and 2.16$ for patients without health insurance. The costs for two radiographs in patients with bilateral ankle trauma was 2.72$ for both feet, and for those without health insurance, 4.32$ for the foot and ankle of one foot. Moreover, the required time for taking radiographs was one hour. Using the two standards would result in preventing the waste of high costs and time for patients.

When assessing the cost effectiveness in the case of using the Ottawa and Bernese rules, it was found that 5.44$ could be saved for each patient if the physicians used the Ottawa and Bernese criteria for the 298 patients with ankle pain, negative Ottawa and Bernese, and no radiographic findings. Moreover, 5.44$ would be saved for each of the 206 patients with unilateral pain in ankle and foot, negative Ottawa and Bernese criteria, and no radiologic findings. Furthermore, 10.88$ would be saved for each of the nine patients with bilateral pain in the feet and ankles, negative Ottawa and Bernese, and no radiologic findings, using the two criteria by the physicians.

Considering the cost-effectiveness for the health system, 8.16$ would be saved for each patient if the physicians and the triage nurses used the two criteria for the 298 patients with pain in the ankle, negative Ottawa, and Bernese, and no radiologic findings of a fracture. 16.32$ would be saved for each patient in the health system, if the physicians and the triage nurses used the two criteria for each of the 20 patients with bilateral pain in ankles, negative Ottawa and Bernese, and no radiologic findings for a fracture.

A more accurate assessment of the two criteria showed the diagnostic value of 90% for Ottawa and 90.75% for Bernese, which were almost equal. After removing the confounding bias, these two methods could replace the use of conventional radiography, prevent the patient's exposure to X-ray, and decrease the costs of ankle injuries to patients.

In general, according to our results, it could be concluded that the sensitivity and specificity of the Bernese criteria in the patients was 91% and 90.7%, respectively. The Ottawa standard's sensitivity and specificity were 97.6% and 88%, respectively, which had a higher sensitivity and a lower specificity than the Bernese criteria. The diagnostic accuracy was 90.75% for Bernese and 90% for Ottawa. The use of both methods and clinical adaptation to the patient's condition, the extent of the lesion, bruising, and swelling is a good criterion for the correct prediction of the fracture without the need for radiography. Generally, the use of the Ottawa standard by emergency personnel is preferred to Bernese in determining the possibility of fracture due to its higher sensitivity. Moreover, using these two methods could reduce the waste of time, energy, and additional costs to the patients during the treatment [21]. This study had some limitations. First, the Bernese

Table 3. Number of radiographs and their costs requested based on OAR and BAR

Variable	All the requested radiographs	Necessary radiographs according to Ottawa standard	Necessary radiographs according to Bernese criterion	Necessary radiographs according to the two criteria	Unnecessary radiographs according to the two criteria
Number of radiographs	2454	782	672	824	1630
Costs	5300.64$	1689.12$	1451.52$	1779.84$	3520.16$
Percent	100%	31.8%	25.5%	33.6%	66.4%

and Ottawa procedures were done by emergency medicine residents which might have a bias in the diagnosis of patients and other related factors. But all of the measurements were confirmed by emergency specialists and orthopedic surgeons and there were no disagreements. However, the physician tried to check the results twice to avoid this bias. Second, radiography results might be interpreted wrongly by the readers.

Acknowledgements

We thank Guilan Road Trauma Research Center, Guilan University of Medical Sciences, Rasht, Iran.

Disclosure of conflict of interest

None.

Address correspondence to: Seyed Mohammad Ghodsi Khorsand, Guilan Road Trauma Research Center, School of Medicine, Guilan University of Medical Sciences, Daneshgah Blvd., Rasht, Iran. Tel: +989132018619; E-mail: Sm.ghodsi@gmail.com

References

[1] Doherty C, Delahunt E, Caulfield B, Hertel J, Ryan J and Bleakley C. The incidence and prevalence of ankle sprain injury: a systematic review and meta-analysis of prospective epidemiological studies. Sports Med 2014; 44: 123-140.

[2] Bulathsinhala L, Hill OT, Scofield DE, Haley TF and Kardouni JR. Epidemiology of ankle sprains and the risk of separation from service in US army soldiers. J Orthop Sports Phys Ther 2015; 45: 477-484.

[3] Jonckheer P, Willems T, De Ridder R, Paulus D, Holdt Henningsen K, San Miguel L, De Sutter A and Roosen P. Evaluating fracture risk in acuteankle sprains: any news since the Ottawa anklerules? A systematic review. Eur J Gen 2016; 22: 31-41.

[4] Akpinar C, Kavalci C, Yilmaz F, Ceyhan MA and Yilmaz MS. The validation of Ottawa ankle rules in a prospective study of 315 consecutive patients: a prevelance study in a single-center. Advances in Research 2014; 225-230.

[5] Fong DT, Hong Y, Chan LK, Yung PS and Chan KM. A systematic review on ankle injury and ankle sprain in sports. Sports Med 2007; 37: 73-94.

[6] Yazdani S, Jahandideh H and Ghofrani H. Validation of the Ottawa ankle rules in Iran: a prospective survey. BMC Emerg Med 2006; 16: 3-6

[7] Shah S, Thomas AC, Noone JM, Blanchette CM and Wikstrom EA. Incidence and cost of ankle sprains in United States emergency departments. Sports Health 2016; 8: 547-552.

[8] Doherty C, Bleakley C, Delahunt E and Holden S. Treatment and prevention of acute and recurrent ankle sprain: an overview of systematic reviews with meta-analysis. Br J Sports Med 2017; 51: 113-125.

[9] Kose O, Gokhan S, Ozhasenekler A, Celiktas M, Yigit S and Gurcan S. Comparison of Ottawa ankle rules and Bernese ankle rules in acute ankle and midfoot injuries. Turk J Emerg Med 2010; 3: 101-103.

[10] Marinelli M, Di Giulio A and Mancini M. Validation of the Ottawa ankle rules in a second-level trauma center in Italy. J Orthop Traumatol 2007; 8: 16-20.

[11] Meena S and Gangary SK. Validation of the Ottawa ankle rules in Indian scenario. Arch Trauma Res 2015; 6: 2-4.

[12] Eggli S, Sclabas GM, Eggli S, Zimmermann H and Exadaktylos AK. The Bernese ankle rules: a fast, reliable test after low-energy, supination-type malleolar and midfoot trauma. J Trauma Acute Care Surg 2005; 59: 1268-1271.

[13] Jenkin M, Sitler MR and Kelly JD. Clinical usefulness of the Ottawa ankle rules for detecting fractures of the ankle and midfoot. J Athl Train 2010; 45: 480-482.

[14] Knudsen R, Vijdea R and Damborg F. Validation of the Ottawa ankle rules in a Danish emergency department. Dan Med Bull 2010; 57: A4142.

[15] Broomhead A and Stuart P. Validation of the Ottawa ankle rules in Australia. Emerg Med 2003; 15: 126-132.

[16] Anis AH, Stiell IG, Stewart DG and Laupacis A. Cost-effectiveness analysis of the Ottawa ankle rules. Ann Emerg Med 1995; 26: 422-428.
[17] Derksen RJ, Knijnenberg LM, Fransen G, Breederveld RS, Heymans MW and Schipper IB. Diagnostic performance of the Bernese versus Ottawa ankle rules: results of a randomised controlled trial. Injury 2015; 46: 1645-1649.
[18] Beceren G, Yolcu S, Tomruk O, Atay T and Baykal Y. Ottawa versus Bernese: which is better? Eur J Trauma Emerg Surg 2013; 39: 147-150.
[19] Bachmann LM, Kolb E, Koller MT, Steurer J and ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review. BMJ 2003; 326: 417.
[20] Stiell IG, McKnight RD, Greenberg GH, McDowell I, Nair RC, Wells GA, Johns C and Worthington JR. Implementation of the Ottawa ankle rules. JAMA 1994; 271: 827-832.
[21] Dowling S, Spooner CH, Liang Y, Dryden DM, Friesen C, Klassen TP and Wright RB. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and midfoot in children: a meta-analysis. Acad Emerg Med 2009; 16: 277-87.