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Validation of the Ottawa ankle rules in a second-level trauma center in Italy

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Abstract Trauma of the foot and ankle is commonly seen in the emergency unit. Nearly all of these patients undergo radiography even though only approximately 15% have clinically significant fractures. The Ottawa ankle rules (OARs) have been designed to reduce the number of unnecessary radiographs ordered for these patients. The objective of this study was to validate the OARs in a Italian trauma center. This prospective study enrolled 248 patients with acute ankle injury from July to October 2006 in the Ospedali Riuniti emergency department. Main outcome measures were: sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios (positive and negative) of the OARs. Sensitivity of the OARs for detecting 42 ankle fractures (29 in the malleolar zone, 4 in the midfoot zone and 4 concomitant in both zones) was 100% for each of the two zones and for both zones. Specificity of the OARs for detecting fractures was 46.5% for both zones, 43.5% for the malleolar zone, and 41.0% for the midfoot zone. Implementation of the OARs had the potential for reducing radiographs by 29%. OARs are highly sensitive tools for detecting ankle and midfoot fractures. Implementation of these rules would reduce the number of radiographs and the associated costs, radiation exposure and waiting times in emergency departments.

Key words Ottawa ankle rules • Foot • Ankle sprain

Introduction

Ankle injuries are one of the most common reasons for presenting to orthopedics emergency departments. However, although only a few of these patients (approximately 15%) have a significant clinical fracture, radiography is performed on almost all patients without leading to a positive diagnostic result in 85% of cases [1–5]. By developing the Ottawa ankle rules (OARs) [3, 6], Stiell and colleagues attempted to help physicians rapidly recognize patients who have no fractures. Using these rules, they succeeded in reducing the number of radiographs ordered by physicians by 26.4% without adversely affecting health care quality [7, 8]. In the OARs, a fracture is diagnosed by evaluating bone tenderness and the patient's ability to bear weight.

Clinical decision-making rules are being increasingly published in the medical literature. These tools can enhance physicians' efficiency and help them effectively challenge their uncertainties in clinical decision-making [9].

OARs have been validated in several different countries [10–20]. In their systematic review, Bachman and coworkers [20] found that the sensitivity of the OARs range from 96.4% to 99.6%, while the specificity ranges from 26.3% to 47.9%. Despite these successful results, however, other studies did not validate the OARs [21–23].

In view of the high prevalence of ankle injuries, the long waiting times in emergency departments for patients without severe trauma, and the increasing calls for more cost-effective methods in clinical practice, we aimed to validate OARs in an emergency department of a second-level trauma center in Italy.

Patients and methods

This prospective study was performed in a 4-month period from July to October 2006 on patients presenting to Ospedali Riuniti Hospital's Emergency Department with ankle pain or tenderness following blunt trauma. We obtained informed consent from all enrolled patients. Patients who were less than 16 years of age or pregnant, those with injuries of more than seven days, those referring for re-evaluation, and those with multiple traumas or a decreased level of consciousness were excluded from study. The definitions of ankle zones based on Stiell studies are as follows: 1. malleolar zone: 6 cm of the distal fibula; 2. 6 cm of the distal fibula tibia; 3. the talus bone; 4. navicular bone; 5. cuboid zone; 6. cuneiform bones; 7. anterior process of calcaneous; 8. the base of the fifth metatarsal bone [3].

Patients were physically examined and evaluated regarding the 8 clinical variables included in the OARs. Each patient's data was recorded and coded. All patients were then referred for standard radiography of the malleolar zone, midfoot zone or both according to the presence of pain or tenderness in one or both of these zones. As defined by Stiell et al. [3], the malleolar zone was 6 cm of the distal fibula and tibia as well as the talus bone, while the midfoot zone included the navicular, cuboid and cuneiform bones, the anterior process of the calcaneus, and the base of the fifth metatarsal bone. Radiography results were interpreted by an orthopedics surgery resident who had not visited or examined the patients and thus was blind to the OAR diagnosis.

Sensitivity, specificity, positive and negative likelihood ratios, and positive and negative predictive values with 95% confidence intervals were calculated.

Results

During the study period, 248 patients of mean age 31.8 years (SD=15.9 years) presented with ankle pain and were included in the study (Table 1). Overall, 162 patients (65.4%) reached the hospital within 12 hours of injury. The more common injury mechanisms were sport activi-

Table 1 Clinical characteristics of 248 patients with ankle pain and tenderness

	Patients,	*n* (%)
Male, *n* (%)	161	(64.9)
Delay between injury and arrival at emergency department		
<3 h	52	(21.0)
4–12 h	110	(44.4)
24–48 h	60	(24.1)
>48 h	26	(10.7)
Mechanism of injury		
Sports activities	52	(20.9)
Descending stairs	30	(12.0)
Falling in pot-holes	27	(10.8)
Twisting ankle during casual walking	35	(14.1)
Direct trauma	25	(10.0)
Falling down	40	(16.1)
Tripping over obstacles	30	(12.0)
Other	9	(4.1)
Fracture type	42	(16.9)
Malleolar zone	31	
Lateral malleolus	16	
Medial malleolus	9	
Bimalleolar	6	
Calcaneus	0	
Talus	0	
Midfoot zone	11	
Base of fifth metatarsal bone	9	
Navicular bone	1	
Cuboid bone	1	
Cuneiforme bone	0	

ties (52 patients, 20.9%) and falling down (40 patients, 16.1%). At radiography, 42 patients (16.9%) were found to have fractures, of which 29 were in the malleolar zone and 9 were in the midfoot zone; 4 patients had a fracture in both zones.

For fractures, the most common therapeutic intervention was application of a short leg cast in 29 patients, while for ligamentous injuries a brace was most often applied (Table 2).

As shown in Table 3, the sensitivity of the OARs in detecting an ankle fracture was 100% (95% CI, 91.8%–100%.) For isolated malleolar injuries the sensitivity was also 100% (95% CI, 85.3%–100%) as it was for isolated midfoot injuries (95% CI, 73.3%–100%) and for concomitant injuries to both zones (95% CI, 32.0%–100%). Despite the high sensitivity this specificity for injuries to the malleolar zone, the midfoot zone and both zones were 43.5% (95% CI, 32.8%–48.1%), 58.6% (95% CI, 31.6%–49.3%), and 46.5% (95% CI, 35.1%–76.9%), respectively. Negative predictive values for malleolar, midfoot and all fractures were 100% (95% CI, 93.8%–100%), 100% (95% CI, 77.4%–100%), and 100% (95% CI, 95.4%–100%), respectively. Negative likelihood ratio was nil for all three evaluations. The positive predictive values of the OARs were 45.9% (95% CI, 13.9%–51.5%) for malleolar zone fractures, 41% (95% CI, 30.0%–74.2%) for midfoot fractures, and 43.3% (95% CI, 19.9%–45.2%) for all fractures. The positive likelihood ratios were 2.3, 1.7 and 17.8 for the malleolar zone, the midfoot zone and the overall evaluation, respectively.

In view of the 72 patients with negative OARs the implementation of the OARs had the potential for reducing radiographs by 29% if we hypotheses that all of 248 patients undergo radiography.

Discussion

Several studies have been performed since 1981 to develop clinical decision-making rules for using radiographs in ankle injuries [2, 4, 5, 8, 10–20]. The OARs were designed, reviewed and validated by their Canadian inventors, and have been used in various clinical settings. The rules have been successfully and favorably validated in the US [12], the UK [5], France [11], the Netherlands [17], Greece [16], Spain [14], Australia [13] and Hong Kong [15]. However, some studies [21–24] have rejected the generalizability of the OARs, although these studies had considerable methodological errors or did not use real rules as described and validated by Stiell and co-workers [8, 23–25].

It is estimated that more than 5 million radiographs are ordered annually in Northern America, costing about US $500 million. It must be noted that multiple low-cost tests such as plain radiography can be as much a financial burden to health care system as high-tech, high-cost but

Table 2 Treatments for 248 patients with ankle injuries, by type of injury

Treatment, *n* (%)	Fracture (*n*=42)	Ligamentous injury (*n*=206)
Brace	3 (7.1)	137 (66.5)
Short leg cast	29 (69.0)	41 (19.9)
Conservative management	0 (0)	24 (11.6)
Surgery	10 (23.8)	0 (0)
Other	0 (0)	4 (1.9)

Table 3 Correspondence between ankle injury diagnosis according to the Ottawa ankle rules (OAR) and the radiological diagnosis, for 248 patients by zone of ankle injury

	Fracture		Ligamentous injury		Total
	OAR^+	OAR^-	OAR^+	OAR^-	
Isolated malleolar injury	29	0	66	51	146
Isolated midfoot injury	9	0	12	17	38
Combined malleolar and midfoot injury	4	0	56	4	64
All injuries	42	0	134	72	248

uncommonly used medical interventions [26–28]. In addition, patients are more satisfied if they do not have to undergo radiography [26].

In our experience, about 70 patients present each day to the Ospedali Riuniti Hospital Emergency Department, and of these approximately 10% have ankle injuries. Thus, of a roughly estimated 25 500 presentations each year, 3650 are only for ankle injuries. Based on the fees confirmed by Ospedali Riuniti Economic Services, anteroposterior and lateral radiographs of the ankle and foot zones cost about 14 euro. Moreover, in most ankle injuries, both radiographs are ordered. If 29% of radiographs could be avoided by using the OARs, savings would reach up to 16 000 euro each year. Also, we should add to this figure the indirect costs saved by reducing the time patients spend in the hospital.

Application of the OARs, however, has some limitations and obstacles. Some studies reported that physicians, despite attending a one-hour training program on the OARs and having a good opinion towards the subject, did not use the OARs [29]. In addition, the rate of radiograph reduction in current practice may not be as high as anticipated, due to patients' anxiety or the physicians' obsession with ordering radiographs even when the required criteria are not met. It should also be noted that, currently, not all patients might accept the physician's avoidance from ordering a radiograph for ankle injuries.

The current study faced some limitations. The relatively low number of cases made it difficult to generalize the results to other medical centers and to the entire Italian population. In addition, because we did not have any case of calcaneus, talus or cuneiform fracture, the achieved results may not be perfectly in view of all fractures in this zone. Interobserver reliability among physicians, residents, and interns was also not determined. Referring all patients for radiography with the subsequent danger of radiation exposure was not an ethical problem, because it is currently the routine procedure for all patients.

One of the weak points of the Ottawa ankle rules is the low specificity of the test, which leads to many false-positive clinical findings. Some authors noticed that direct palpation of the bone with the fingertip produces pain, not only in acutely injured patients but also in numerous uninjured, mainly female individuals. This is because the tender periosteum is located superficially at this anatomic site. Eggli and co-workers [30] introduced a new clinical test to examine the ankle and midfoot by applying indirect forces to the injured region without direct compression of the bone. Compared with the original OARs, the number of false-positive findings was significantly reduced, resulting in an 84% reduction in radiographs after low-energy, supination-type ankle and midfoot trauma. The authors concluded that further investigations have to be performed to prove whether these findings are reproducible within other clinical settings, which could result in major cost savings for the health care system [30].

Our validitation study of the OARs obtained results similar to the majority of other investigations. The sensitivity of these rules was 100% for diagnosing ankle and midfoot fractures. Application of these rules could have reduced the number of radiographs by approximately 29%. Thus, OAR application can not only decrease the number of radiology department referrals, but also can reduce costs and radiation exposure and save time for hospital staff and patients.

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