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Original Contribution

Retrospective comparison of the Low Risk Ankle Rules and the Ottawa Ankle Rules in a pediatric population

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ABSTRACT

Background: A recent multicenter prospective Canadian study presented prospective evidence supporting the Low Risk Ankle Rules (LRAR) as a means of reducing the number of ankle radiographs ordered for children presenting with an ankle injury while maintaining nearly 100% sensitivity. This is in contrast to a previous prospective study which showed that this rule yielded only 87% sensitivity.
Objective: It is important to further investigate the LRAR and compare them with the already validated Ottawa Ankle Rules (OAR) to potentially curb healthcare costs and decrease unnecessary radiation exposure without compromising diagnostic accuracy.
Methods: We conducted a retrospective chart review of 980 qualifying patients ages 12 months to 18 years presenting with ankle injury to a commonly staffed 310 bed children's hospital and auxiliary site pediatric emergency department.
Results: There were 28 high-risk fractures identified. The Ottawa Ankle Rules had a sensitivity of 100% (95% CI 87.7–100), specificity of 33.1% (95% CI 30.1–36.2), and would have reduced the number of ankle radiographs ordered by 32.1%. The Low Risk Ankle Rules had a sensitivity of 85.7% (95% CI 85.7–96), specificity of 64.9% (95% CI 61.8–68), and would have reduced the number of ankle radiographs ordered by 63.1%. The latter rule missed 4 high-risk fractures.
Conclusion: The Low Risk Ankle Rules may not be sensitive enough for use in Pediatric Emergency Departments, while the Ottawa Ankle Rules again demonstrated 100% sensitivity. Further research on ways to implement the Ottawa Ankle Rules and maximize its ability to decrease wait times, healthcare costs, and improve patient satisfaction are needed.

1. Introduction

With healthcare costs in the United States continuing to rise and emergency department becoming overcrowded [1,2] it becomes crucial to find ways to cut costs without compromising healthcare quality. Pediatric Emergency Departments (PEDs) are an important setting to cut costs while maintaining quality.

Roughly 85–100% of children presenting to United States PEDs with a history of ankle injury receive an ankle radiograph [3]. While the Ottawa Ankle Rule (OAR) has been validated for use in the pediatric population [4], a less well-studied rule, the Low Risk Ankle Rule (LRAR), has also shown promising results. A large multicenter prospective study conducted in Canada and published in 2013 suggested that the LRAR could reduce the number of ankle x-rays performed in PEDs by up to 60%, while maintaining nearly 100% sensitivity [5]. While such results are promising, further validation is needed prior to implementation. This is particularly true given that a smaller 272 subject prospective study performed several years earlier showed only 87% sensitivity for the LRAR, missing 6 clinically significant fractures, versus 100% sensitivity for the OAR [6].

Thus, our aim was to further investigate the LRAR and to compare this clinical decision rule to the well-validated OAR in a pediatric population. To the best of our knowledge, there has never been a retrospective study comparing the two clinical decision rules, which could provide another perspective and eliminate possible expectation bias introduced by non-blinded clinicians in prior discordant prospective studies.

2. Methods

2.1. Definitions

The Low Risk Ankle Rules state that an ankle radiograph is not required if an ankle examination reveals tenderness and swelling isolated to the distal fibula and/or adjacent lateral ligaments distal to the tibial

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anterior joint line [7]. The Ottawa Ankle Rules state that an ankle radiograph is required if examination reveals pain in the malleolar zone and one of the following: 1) inability to bear weight immediately after the injury and in the Emergency Department for four steps or 2) bone tenderness along the distal 6 cm of the posterior edge of the tibia or tip of the medial malleolus 3) bone tenderness along the distal 6 cm of the posterior edge of the fibula or tip of the lateral malleolus [8]. A high-risk ankle injury is defined as any fracture of the foot, distal tibia, and fibula proximal to the distal physis; tibiofibular syndesmosis injury, or ankle dislocation, with increased risk of requiring surgical intervention [5].

2.2. Study design and data collection

We conducted an institutional review board (IRB) approved retrospective chart review at a 310 bed children's hospital and one auxiliary site. We used the radiology search engine Montage (Philadelphia, Pennsylvania) to identify all ankle x-rays performed on patients between 12 months and 18 years of age at either PED between 1/1/2011 and 4/30/2014. Relevant data including patient gender, age, presence and type of fracture were accessed in January 2015 and manually entered into an Excel spreadsheet. Each ankle radiograph series had already been interpreted by an attending fellowship-trained pediatric radiologist. If the radiographic report impression was indeterminate for the presence of a fracture, the subject was excluded from the study. Otherwise, the radiologic interpretation as to whether a fracture was present and if so, what type of fracture was entered into the study data spreadsheet. The accession numbers obtained from Montage were entered into our picture archiving and communication system (PACS, Synapse, Fujifilm) in order to obtain the patient's medical record number (MRN).

The MRN was then used to obtain the patient's electronic medical record (Cerner, Kansas City) note in order to determine if the patient met criteria for ankle x-ray under each the OAR and the LRAR criteria. If there was inadequate documentation in the patient's EMR note to make this determination for either rule, the subject was excluded.

Additional exclusion criteria included inability to walk prior to ankle injury, physical deformity on exam, previous diagnosis of fracture, and underlying disease that could influence decision for x-ray (these conditions included history of bony neoplasm, sickle cell disease, osteogenesis imperfecta and osteopetrosis) (Table 1).

2.3. Statistical methods

The baseline characteristics of the study subjects were summarized in terms of counts and percentages, or means (standard deviation), and ranges. All data were analyzed using Stata IC/13.1 (College Station, TX).

The same set of analyses were performed for both of the clinical decision rules (Ottawa Ankle Rules and the Low Risk Ankle Rules) and three different age groups of patients: 1) all patients (1–18 y), 2) preschool-adolescents (3–16 y), and 3) toddlers (1–2 y). The age range for the second group was chosen because it is similar to what was used in other published studies [5,8].

Table 1
Eligibility status of all subjects who received an ankle radiograph in the emergency department.

Total number of age-eligible exams (≥1 and ≤ 18 years) identified using Montage	N = 1378
Number of excluded cases	
X-ray report indeterminate for fracture	71
Exam data insufficient to determine if OAR criteria met	218
Already diagnosed with fracture, presenting for post-reduction	15
Underlying disease that could predispose to fracture (e.g. osteogenesis imperfecta)	18
Obvious physical deformity on exam	6
Exam data insufficient to determine if LRAR criteria met	70
Total number of eligible exams	N = 980

Sensitivity was calculated as the percentage of patients with a radiographically-confirmed high-risk fracture that would have been correctly identified by applying the clinical decision rule in the PED. Likewise, specificity was calculated as the percentage of patients without a radiographically confirmed high-risk fracture that would have been correctly identified by applying the clinical decision rule. MedCalc's online diagnostic test evaluation calculator was used to generate the estimates and 95% confidence intervals for sensitivity and specificity [9].

The potential reduction in ankle radiographs was expressed as a percent reduction and was calculated as follows: [Total number of radiographs actually performed − number of radiographs that would have been ordered solely based on the clinical decision rule] / total number of radiographs actually performed) * 100.

The number of radiographically confirmed high-risk fractures that would have been missed by each of the clinical decision rules was recorded along with the total number of radiographically confirmed high-risk fractures that actually occurred in each group.

3. Results

A total of 980 subjects with an average age of 11.7 years (range 1–18) met the inclusion criteria (Table 2). A mere 21/980 (2%) reviewed charts mentioned the Ottawa Ankle Rules and 0/980 (0%) mentioned the Low Risk Ankle Rules as justification for obtaining an ankle x-ray. There were a total of 28 high-risk fractures within the study population.

Systematically applying the OAR in the ER to these 980 patients would have identified all 28 high-risk ankle fractures, with 100% sensitivity and 33.1% specificity and reduced the number of ankle x-rays ordered by 32.1%. Systematically applying the LRAR in the ER would have missed 4 high-risk ankle fractures, including a spiral fracture of the tibia and Salter Harris II, III, and IV fractures of the tibia. The LRAR had 85.7% sensitivity and 64.9% specificity. The LRAR would have decreased the number of ankle x-rays ordered by 63.1% (Table 3).

Additional analyses performed after excluding subjects <3 and >16 years of age (in line with the age criteria used in the recent multicenter Canadian study investigating the LRAR [5] and many of the studies on the OAR [6]) showed similar results as compared to the analysis that included all 980 subjects ages 1 through 18 years.

When the same analysis was performed on the very youngest group of children (1 to 2 years of age), both the OAR and LRAR had 100% sensitivity and 77.8% specificity. However, these are rather imprecise estimates (as evidenced by the wide confidence intervals) because they were based on a very small group of children (n = 29) with only 2 high-risk fractures.

4. Discussion

The sensitivity of the LRAR among children 1–18 years of age in our study was lower than that found in the 2013 study by Boutis et al. [5], but similar to those of the 2009 study by Gravel et al. [6]. As with the

Table 2
Characteristics of the study population (N = 980).

Characteristic	
Age (y)[a]	11.7 (4.0)
Sex[b]	
Male	485 (49.5)
Female	495 (50.5)
Duration of symptoms[b]	
≤24 h	720 (73.5)
>24–≤72 h	134 (13.6)
>72 h	81 (8.3)
Unknown	45 (4.6)
High risk fractures[c]	28

[a] Mean (SD).
[b] n(%).
[c] (n).