Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review

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Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review

Lucas M Bachmann, Esther Kolb, Michael T Koller, Johann Steurer, Gerben ter Riet

Abstract

Objective To summarise the evidence on accuracy of the Ottawa ankle rules, a decision aid for excluding fractures of the ankle and mid-foot.

Design Systematic review.

Data sources Electronic databases, reference lists of included studies, and experts.

Review methods Data were extracted on the study population, the type of Ottawa ankle rules used, and methods. Sensitivities, but not specificities, were pooled using the bootstrap after inspection of the receiver operating characteristics plot. Negative likelihood ratios were pooled for several subgroups, correcting for four main methodological threats to validity.

Results 32 studies met the inclusion criteria and 27 studies reporting on 15 581 patients were used for meta-analysis. The pooled negative likelihood ratios for the ankle and mid-foot were 0.08 (95% confidence interval 0.03 to 0.18) and 0.08 (0.03 to 0.20), respectively. The pooled negative likelihood ratio for both regions in children was 0.07 (0.03 to 0.18). Applying these ratios to a 15% prevalence of fracture gave a less than 1.4% probability of actual fracture in these subgroups.

Conclusion Evidence supports the Ottawa ankle rules as an accurate instrument for excluding fractures of the ankle and mid-foot. The instrument has a sensitivity of almost 100% and a modest specificity, and its use should reduce the number of unnecessary radiographs by 30–40%.

Introduction

The number of acute ankle sprains managed by lay people at sporting activities is unknown; however, general practitioners frequently encounter such injuries.1 The management of ankle sprains is daily routine at emergency departments, and although most patients undergo radiography, fracture of the ankle or mid-foot occurs in less than 15%.2-6 This small yield triggered the development of the Ottawa ankle rules in 1992.7 This instrument consists of a questionnaire for assessment of the ankle and foot.3 The ankle assessment covers the ability to walk four steps (immediately after the injury or at the emergency department) and notes localised tenderness of the posterior edge or tip of either malleolus (four spots). The mid-foot assessment covers the ability to walk and notes localised tenderness of the navicular or the base of the fifth metatarsal (fig 1). The instrument is designed to rule out fractures of the malleolus and the mid-foot. It has been validated and modified in several clinical settings.

When almost every patient entering the emergency department with an ankle sprain undergoes radiography, even modest values for specificity may imply large reductions in the number of radiographs needed. The instrument is therefore calibrated towards high sensitivity, at the expense of specificity to some extent. We conducted a systematic review on the accuracy of the Ottawa ankle rules.

Methods

We focused on studies in which the Ottawa ankle rules was used to diagnose fractures of the ankle or mid-foot. We electronically searched databases, checked the reference lists of included studies, and contacted experts and authors in the specialty (see appendix on bmj.com).

We searched Medline and Premedline (Ovid version; 1990 to present), Embase (Datastar version; 1990-2002), CINAHL (Winsirs version; 1990-2002), and the Cochrane Library (2002, issue 2). We explored the Science Citation Index database (Web of Science by Institute for Scientific Information), entering reference 7 of this paper. The search had no language restrictions.

We selected studies in a two stage process. Firstly, all abstracts or titles found by the electronic searches were independently scrutinised by JS and LMB. If a paper's eligibility was disputed, the paper was obtained and scrutinised. Next, we obtained copies of eligible papers. We used a checklist to assess that criteria for inclusion had been met. Minimal requirements for inclusion were assessment of the Ottawa ankle rules and the possibility of constructing at least a 2×2 table specifying the false positive rate and the false negative rate. Disagreements on eligibility of studies were resolved by consensus.

Methodological quality and statistical analysis

EK and LMB independently assessed the methods of data collection, patient selection, blinding and prevention of verification bias, and description of the instrument and reference standard.2-6 Disagreements were resolved by consensus.
Results

We identified 1085 studies from the electronic search, and we obtained full papers for 116. The reference lists of these studies revealed 15 additional articles. Overall, we analysed 32 studies meeting our inclusion criteria.7–46 Contact with the first authors of these studies yielded no additional data.

Overall, 32 studies investigated the accuracy of the Ottawa ankle rules: 16 assessed the ankle,7–10 13–15 17–23 26 28 34 37 38 43 45 46 and 10 investigated global accuracy, which included a combination of both assessments.

The Ottawa ankle rules was developed to assist decision making in adults, but six studies reported on the accuracy of the instrument in children.11–13 Several studies selectively included patients admitted to the hospital within 48 hours of a sprain instead of within one week.22 30 31 36

Pooled analyses

We excluded from the pooled estimates studies that collected data non-prospectively in addition to unknown blinding of the radiologist7–10 and one abstract.80 If studies compared the performance of dif-

Table 1 Pooled likelihood ratios (95% confidence intervals; random effects) of negative result with Ottawa ankle rules for subgroups of increasing complexity of methodological quality

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Prospective data collection</th>
<th>Plus consecutive enrolment</th>
<th>Plus blinding</th>
<th>Plus radiography as reference standard in all patients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Within 48 hours</td>
<td>After 48 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n=4</td>
<td>n=12</td>
<td>n=5</td>
<td></td>
</tr>
<tr>
<td>Ankle</td>
<td>0.01</td>
<td>0.09*</td>
<td>0.08</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(0.08 to 0.22)</td>
<td>(0.04 to 0.22)</td>
<td>(0.02 to 0.39)</td>
<td>(0.01 to 0.44)</td>
</tr>
<tr>
<td>Mid-foot</td>
<td>—</td>
<td>0.08</td>
<td>0.08</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>(0.03 to 0.21)</td>
<td>(0.01 to 0.77)</td>
<td>(0.003 to 1.74)</td>
<td>(0.03 to 0.21)</td>
</tr>
<tr>
<td>Combined</td>
<td>—</td>
<td>—</td>
<td>0.26</td>
<td>0.26</td>
</tr>
<tr>
<td></td>
<td>(0.12 to 0.38)</td>
<td>(0.13 to 0.51)</td>
<td>(0.12 to 0.71)</td>
<td>(0.12 to 0.38)</td>
</tr>
<tr>
<td>Children</td>
<td>0.08</td>
<td>0.08</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td>(0.02 to 0.29)</td>
<td>(0.02 to 0.25)</td>
<td>(0.01 to 1.64)</td>
<td>(0.01 to 1.64)</td>
</tr>
<tr>
<td></td>
<td>n=6</td>
<td>n=4</td>
<td>n=3</td>
<td></td>
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<tr>
<td></td>
<td>n=9</td>
<td>n=4</td>
<td>n=3</td>
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<td>n=6</td>
<td>n=4</td>
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<td></td>
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<tr>
<td></td>
<td>n=10</td>
<td>n=10</td>
<td>n=7</td>
<td></td>
</tr>
</tbody>
</table>

*Larger negative likelihood ratios in studies testing Ottawa ankle rules in mixed populations (ankle and mid-foot versus combined; P<0.001).

We calculated several pooled estimates of the negative likelihood ratio by successively increasing the number of methodological criteria required (table 1).

We calculated sensitivities, specificities, likelihood ratios, and their standard errors. Because the Ottawa ankle rules is calibrated towards high sensitivity, we were particularly interested in the pooled sensitivity (using the bootstrap) and in the pooled likelihood ratio of a negative result (using a random effects model)—that is, how many times more likely it is to find a negative result among people with a fracture (1−sensitivity) than among those without (specificity). To investigate sources of variation in the negative likelihood ratios, we looked at this variable in analyses stratified by variables related to clinical subgroups and study design. We calculated the Spearman rank correlation to assess variation in diagnostic threshold. We tested heterogeneity of sensitivities and specificities using χ² tests, but the interpretation was hampered by small numbers of false negative results.81 After inspection of the receiver operating characteristics plot we decided to pool sensitivities, but not specificities (fig 2).

We analysed the data with Stata 7.0.

Fig 1 Ottawa ankle rules

Fig 2 Receiver operating characteristics plot of all included studies (39 2×2 tables)
ferent specialties using the rules, we analysed only the data on doctors’ judgments.\textsuperscript{31, 35} We also excluded from the pooled analysis data on modifications of the rules.\textsuperscript{27–28, 41, 44}

Overall, 27 studies were available for the pooled analysis: 12 on assessment of the ankle (13 2×2 tables),\textsuperscript{7, 16, 18, 26, 30, 31, 33, 34, 42, 45, 46} eight on assessment of the mid-foot (nine 2×2 tables),\textsuperscript{7, 16, 19, 20, 24, 29, 32, 36} and six on assessment of the ankle or mid-foot in children (seven 2×2 tables).\textsuperscript{39, 30, 24, 29, 32, 36} Among these 27 studies describing 15,581 patients, 47 patients (0.3%) had a false negative result. Table 2

<table>
<thead>
<tr>
<th>Study</th>
<th>No of patients</th>
<th>Specification</th>
<th>Prospective data collection</th>
<th>Exclusion of patients &lt;18 years</th>
<th>Mean age</th>
<th>Consecutive enrolment</th>
<th>Blinding of radiologist</th>
<th>Radiography in all patients</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ankle assessment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aginaga et al 1999\textsuperscript{9}</td>
<td>463</td>
<td>Doctors applied OARs in adults in regional hospital in Spain</td>
<td>Yes</td>
<td>Yes</td>
<td>37.1</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Auleley et al 1998\textsuperscript{8}</td>
<td>130</td>
<td>Compared radiography request rates between senior house officers and nurse practitioners using OARs in adults in university hospital in France</td>
<td>Yes</td>
<td>Yes</td>
<td>34</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Kerr et al 1984\textsuperscript{10}</td>
<td>350</td>
<td>OARs applied in convenience (not otherwise specified; easy to approach) sample of adults in four hospitals (two university, one community, and one provincial) in New Zealand. Mid-foot injuries not assessed</td>
<td>Yes</td>
<td>Not reported</td>
<td></td>
<td>Not reported</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lucchesi et al 1995\textsuperscript{11}</td>
<td>422</td>
<td>OARs in convenience sample of adults in suburban community teaching trauma centre in United States</td>
<td>Yes</td>
<td>Yes</td>
<td>35</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Mann et al 1998\textsuperscript{12}</td>
<td>700</td>
<td>Compared radiography request rates between senior house officers and nurse practitioners applying OARs in patients enrolled within 48 hours after injury to large accident and emergency department in United Kingdom. No mid-foot assessment</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>Not reported</td>
<td>Not reported</td>
<td>Yes</td>
</tr>
<tr>
<td>Papacostas et al 2001\textsuperscript{13}</td>
<td>79</td>
<td>OARs in athletes and people engaged in sport at least three times a week, injured during sports activities attending district general hospital and sports injuries clinic in Greece</td>
<td>Yes</td>
<td>Yes</td>
<td>29</td>
<td>Not reported</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Perry et al 1999\textsuperscript{14}</td>
<td>577</td>
<td>OARs assessed in urban teaching hospital in United Kingdom. No mid-foot assessment reported</td>
<td>Yes</td>
<td>Yes</td>
<td></td>
<td>Not reported</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Singh-Ranger and Marathias 1999\textsuperscript{15}</td>
<td>18</td>
<td>Compared conventional ordering of radiography to use of OARs in district general hospital in United Kingdom. No mid-foot assessment reported</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td>Not reported</td>
<td>Yes</td>
<td>Not reported</td>
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<tr>
<td>Stiell et al 1992\textsuperscript{16}</td>
<td>889</td>
<td>Development of OARs in two university hospital emergency departments in Canada</td>
<td>Yes</td>
<td>Yes</td>
<td>35.1</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1993\textsuperscript{17}</td>
<td>1032</td>
<td>OARs applied in adults attending one of two university hospital emergency departments in Canada. Refinement of 1992 rules</td>
<td>Yes</td>
<td>Yes</td>
<td>35</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1993\textsuperscript{18}</td>
<td>453</td>
<td>OARs applied in adults attending one of two university hospital emergency departments in Canada. Validation of refined rules</td>
<td>Yes</td>
<td>Yes</td>
<td>36</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1994\textsuperscript{19}</td>
<td>565</td>
<td>Implementation study of OARs using refined 1993 OARs. OARs applied on adults attending university hospital in Canada</td>
<td>Yes</td>
<td>Yes</td>
<td>36</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yuen et al 2001\textsuperscript{20}</td>
<td>467</td>
<td>OARs applied in Chinese population of district hospital of Hong Kong</td>
<td>Yes</td>
<td>No</td>
<td>37</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Foot assessment</strong></td>
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<td></td>
</tr>
<tr>
<td>Aginaga et al 1999\textsuperscript{9}</td>
<td>197</td>
<td>Doctors applied OARs on adults in regional hospital in Spain</td>
<td>Yes</td>
<td>Yes</td>
<td>37.1</td>
<td>Not reported</td>
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</tr>
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<td>Yes</td>
<td>34</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Lucchesi et al 1995\textsuperscript{11}</td>
<td>150</td>
<td>OARs applied in convenience sample of adults of suburban community teaching trauma centre in United States</td>
<td>Yes</td>
<td>Yes</td>
<td>35</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Papacostas et al 2001\textsuperscript{13}</td>
<td>43</td>
<td>OARs in athletes and people engaged in sport at least three times a week, injured during sports activities attending district general hospital and sports injuries clinic in Greece</td>
<td>Yes</td>
<td>Yes</td>
<td>29</td>
<td>Not reported</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Table 2 Description of 27 studies on diagnostic accuracy of Ottawa ankle rules (OARs). See appendix for description of all 32 studies—continued from previous page

<table>
<thead>
<tr>
<th>Study</th>
<th>No of patients</th>
<th>Specification</th>
<th>Prospective data collection</th>
<th>Exclusion of patients &lt;18 years</th>
<th>Mean age</th>
<th>Consecutive enrolment</th>
<th>Blinding of radiologist</th>
<th>Radiography in all patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stiell et al 1992</td>
<td>689</td>
<td>Development of OARs in two university hospital emergency departments in Canada</td>
<td>Yes</td>
<td>Yes</td>
<td>35.1</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1993</td>
<td>1032</td>
<td>OARs applied in adults attending one of two university hospital emergency departments in Canada. Refinement of 1992 rules</td>
<td>Yes</td>
<td>Yes</td>
<td>35</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1993</td>
<td>453</td>
<td>OARs applied in adults attending one of two university hospital emergency departments in Canada. Validation of refined rules</td>
<td>Yes</td>
<td>Yes</td>
<td>38</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Stiell et al 1994</td>
<td>565</td>
<td>Implementation study of OARs using refined 1993 OARs. OARs applied on adults attending university hospital in Canada</td>
<td>Yes</td>
<td>Yes</td>
<td>38</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Yuen et al 2001</td>
<td>467</td>
<td>OARs applied in Chinese population of district hospital in Hong Kong</td>
<td>Yes</td>
<td>No</td>
<td>37</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Combined assessment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chandra and Schafmayer</td>
<td>397</td>
<td>OARs applied in adults attending city hospital in Germany</td>
<td>Yes</td>
<td>Yes</td>
<td>Not reported</td>
<td>No</td>
<td>Not reported</td>
<td>Yes</td>
</tr>
<tr>
<td>Garcia et al 2001</td>
<td>494</td>
<td>OARs in two community hospitals in Spain</td>
<td>Yes</td>
<td>Yes</td>
<td>35.6</td>
<td>Not reported</td>
<td>Not reported</td>
<td>Yes</td>
</tr>
<tr>
<td>Glas et al 2002</td>
<td>647</td>
<td>Compared OARs and Leiden ankle rule assessed in adults of mid-sized teaching hospital in Netherlands.</td>
<td>Yes</td>
<td>Yes</td>
<td>35</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Keogh et al 1998</td>
<td>262</td>
<td>Compared current local guidelines with OARs in patients &gt;16 years attending teaching hospital in United Kingdom</td>
<td>Yes</td>
<td>No</td>
<td>32</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Leddy et al 1998</td>
<td>78</td>
<td>OARs applied in patients &gt;12 years, attending university based community sports medical centre in the United States</td>
<td>Yes</td>
<td>No</td>
<td>23.4</td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>McBride 1997</td>
<td>259</td>
<td>OARs applied in adults attending common practice with family doctors in community hospital in Canada</td>
<td>Yes</td>
<td>No</td>
<td>30.9</td>
<td>No</td>
<td>Not reported</td>
<td>Yes</td>
</tr>
<tr>
<td>Pigman et al 1994</td>
<td>71</td>
<td>OARs used by attending doctors and triage nurses at community and university hospital in United States</td>
<td>Yes</td>
<td>No</td>
<td>35</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Salt and Clancy 1997</td>
<td>324</td>
<td>OARs used by triage nurses at university hospital in United Kingdom. Radiography performed on discretion of treating doctor</td>
<td>Yes</td>
<td>Yes</td>
<td>Not reported</td>
<td>Yes</td>
<td>Not reported</td>
<td>No</td>
</tr>
<tr>
<td>Tay et al 1999</td>
<td>488</td>
<td>OARs in Asian population (Chinese, Malay, and Indian) attending large teaching hospital in Singapore</td>
<td>Yes</td>
<td>No</td>
<td>Not reported</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Verma et al 1996</td>
<td>911</td>
<td>OARs applied in adults attending level 1 trauma centre in Cincinnati, United States</td>
<td>Yes</td>
<td>Yes</td>
<td>Not reported</td>
<td>Not reported</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Children</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boutis et al 2001</td>
<td>607</td>
<td>Clinical examination compared with OARs to identify high risk diagnoses in children attending one of two urban, university affiliated paediatric emergency departments in Canada</td>
<td>Yes</td>
<td>No</td>
<td>12.5</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chande 1995</td>
<td>68</td>
<td>OAR applied in children enrolled within 48 hours after injury at University Hospital of Cleveland, United States</td>
<td>Yes</td>
<td>No</td>
<td>12</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Karpas et al 2002</td>
<td>186</td>
<td>Paediatric emergency department nurses applying OARs within 48 hours after injury in children attending tertiary care facility in United States</td>
<td>Yes</td>
<td>No</td>
<td>13</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Libetta et al 1999</td>
<td>781</td>
<td>OARs applied in children &gt;1 year old, attending large teaching hospital in United Kingdom</td>
<td>Yes</td>
<td>No</td>
<td>11</td>
<td>Not reported</td>
<td>Not reported</td>
<td>No</td>
</tr>
<tr>
<td>McBride 1997</td>
<td>37</td>
<td>OARs applied in children attending common practice with family doctors in community hospital in Canada</td>
<td>Yes</td>
<td>No</td>
<td>13.2</td>
<td>No</td>
<td>Not reported</td>
<td>Yes</td>
</tr>
<tr>
<td>Plint et al 1989</td>
<td>559</td>
<td>OARs applied in children attending one of two specialist tertiary care units in Canada within 48 hours after injury. Ankle assessment</td>
<td>Yes</td>
<td>No</td>
<td>12.6</td>
<td>Not reported</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Plint et al 1989</td>
<td>205</td>
<td>OARs applied in children attending one of two specialist tertiary care units in Canada within 48 hours after injury. Foot assessment</td>
<td>Yes</td>
<td>No</td>
<td>12.6</td>
<td>Not reported</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
shows the studies’ characteristics stratified by ankle, mid-foot, or combined assessment.

**Sensitivity and specificity**

Table 3 shows the pooled sensitivities and the distribution of specificities stratified by several characteristics. Sensitivities were consistently high but ranged from 99.6% (95% confidence interval 98.2% to 100.0%) in studies on application of the rules within 48 hours of injury to 96.4% (93.8% to 98.6%) in studies of combined assessment. The specificities ranged from 47.9% (interquartile range 42.3%-77.1%) in studies with a prevalence of fracture below the 25th centile of all studies to 26.3% (19.4%-34.3%) in studies of combined assessment.

**Negative likelihood ratio**

Table 4 shows pooled negative likelihood ratios for clinical subgroups and probabilities of fracture after a negative result, assuming a 15% prevalence of fracture. The post-test probability of fracture was lowest in those studies with prevalences below the 25th centile of all studies (0.7%, 0.53% to 1.90%) and highest in those studies with prevalences above the 75th centile of all studies (3.74%, 1.73% to 8.26%). As the pretest probability of fracture increases, the pooled negative likelihood ratio gets worse. In studies assessing the Ottawa ankle rules in children, the probability of fracture after a negative result was 1.22% (0.53% to 3.08%). A worse negative likelihood ratio was found in the studies that assessed both the ankle and the mid-foot.

Table 5 shows the likelihood ratios for three criteria believed to affect the accuracy of diagnosis. The features of ideal study design, such as consecutive entry and applying a radiography reference standard in all patients, were associated with slightly worse likelihood ratios.

Table 1 shows pooled negative likelihood ratios stratified for delay of patients being assessed (within or after 48 hours) and according to the quality items prospective data collection, enrolment of consecutive patients, blinding of assessor of radiographs, and definite diagnosis with radiography in all patients. Data on the use of the Ottawa ankle rules within 48 hours in adults are scarce. In children, the pooled negative likelihood ratio was 0.07, which seems low enough to be useful, although the evidence is sparse and the confidence interval correspondingly wide. The pooled likelihood ratios for assessment of the ankle and mid-foot are similar irrespective of methodological quality. Nevertheless, the estimates further towards the right side of the table are more likely to be valid.

**Discussion**

We summarised the accuracy of the Ottawa ankle rules for excluding fractures of the ankle and mid-foot in patients presenting to emergency departments with an acute ankle sprain. Less than 2% of patients in most subgroups who were negative for fracture according to the Ottawa ankle rules actually had a fracture.

As the Ottawa ankle rules is an instrument that is calibrated towards high sensitivity, we were particularly interested in the pooled sensitivity and the pooled likelihood ratio of a negative result. Specificity, however, is an indicator of the number of unnecessary radiographs that may be avoided with this decision rule. The variability in the specificities, which ranged from 10% to 79%, is surprising.9 12

We hypothesise that differences in clinical skills, interpretation of the test, and experience of staff
performing the test influenced the accuracy of the Ottawa ankle rules. Only a few studies reported particulars of staff performing the test, stating, for instance, the number of years worked at a trauma emergency department. In addition, the expression of pain, which is crucial for the interpretation of the test, may have a cultural dimension. This could result in a higher false positive rate among patients with a relatively vivid expression of pain or a higher false negative rate among stoical individuals, unless the clinician shares the patient's cultural background. The sublety of palpation technique might explain some of the large variation in false positive rates—the percentages of patients who apparently indicated pain (or were unable to walk four steps) but had no fracture.

The Ottawa ankle rules were developed to avoid unnecessary radiography. The economic aspect of the test may be more complex. An obvious requirement of unnecessary radiography. The economic aspect of the test may be more complex. An obvious requirement of


(Accepted 2 December 2002)
Meaning of the study
We believe that publishing surgeon specific, crude mortality data, as is planned in the United Kingdom, is not in the best interests of patients, and our study shows that surgeons cannot be compared fairly in this way. Cardiac surgeons already work in a stressful environment, and the perception that a “bad run” might jeopardise their career or result in suspension and investigation may lead to a tendency to turn down high risk cases. The easiest way to obtain low mortality is to do only straightforward operations—so called risk averse behaviour. This has already been identified as a potential problem after a survey of all cardiac surgeons in the United Kingdom in 2000, where 94% of responders agreed that high risk patients were being turned down for surgery. Death rates in these patients often approach 100% if the patients are denied surgery and patients at heightened risk from surgery are, in general, those who have the most to gain from a successful operation. Our recommendation of benchmarking only low risk patients seems scientifically justified and pragmatic and should help to prevent risk averse behaviour.

Unanswered questions and future research
Some evidence from North America sheds light on the effects of publication of surgeon specific data on patients, cardiologists, and surgeons, but we do not know to what extent initiatives to publish crude mortality data for individual surgeons will actually deny operations to high risk patients, and what implications this will have on patients’ survival, quality of life, and use of healthcare resources. This is an important area for future studies. Further investigations are also needed on high risk patients, to improve the quality of risk prediction in this group, and to understand variability in outcomes following high risk surgery for quality improvement purposes.

This study has been conducted on behalf of the North West Quality Improvement Programme in Cardiac Interventions, and the participating consultant surgeons are listed as follows: John Au, Ben Bridgewater, Colin Campbell, John Carey, John Chalmers, Waldh Dinhis, Abdal Deiranyia, Andrew Duncan, Fabri, Elaine Griffihis, Gehr Grote, Ragheb Hansen, Tim Hooper, Mark Jones, Daniel Keenan, Nenrag Mediratta, Russell Milliner, Nick Olmm, Brian Peregrinart, Mark Pullan, Abbas Rashid, Paul Waterworth, Nizar Yonan. We would like to acknowledge the assistance of the audit officers working in each centre for their hard work in collecting and validating the data.

Contributors: BB had the idea for the study and with ADG and MJ was responsible for the study design. Data analysis was performed by ADG and MJ. The manuscript was prepared by BB and ADG. All authors contributed to writing the paper, which was written on behalf of the North West Quality Improvement Programme in Cardiac Interventions. ADG will act as guarantor.

Funding: All primary care trusts in the north west of England.

Competing interests: None declared.

Ethical approval: The project was conducted on routinely collected prospective data. All patient identifiers were anonymised. The study therefore did not need ethical approval.

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Corrections and clarifications
ABC of diabetes: cardiovascular disease, hypertension, and lipids
Owing to an electronic problem, we had to retype many of the symbols in this article by Peter J Watkins, and inevitably we slipped up on one (19 April, pp 874-6). The fourth paragraph in the section on blood pressure management should read: “Blood pressure > 140/80 mm Hg [not < 140/80 mm Hg] should be treated if there is evidence of organ damage . . . The target pressure is < 140/80 mm Hg.”

Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systematic review
An error crept into the diagram of the Ottawa ankle rules in this article by Lucas M Bachmann and colleagues (22 February, pp 417-9). The medial view of the ankle should have been labelled: “Posterior edge or tip of the medial [not lateral] malleolus—6 cm.”