Abstract—We sought to validate a set of criteria that predict, with a high degree of sensitivity, which patients may safely forgo pelvic radiography in their initial trauma evaluation. This is a prospective observational study. Adult blunt trauma patients presenting from July 1, 2002 to June 30, 2003 who underwent pelvic radiography were eligible for the study. Physicians completed data sheets that outlined five criteria (altered level of consciousness, complaint of pelvic pain, pelvic tenderness on examination, distracting injury, clinical intoxication) before viewing pelvic radiographs. Final radiographic results were later added. Fractures were classified as clinically significant or insignificant based on the Tile classification. There were 973 patients enrolled in the study; 62 patients had pelvic fractures (prevalence 6.4%). The decision instrument predicted fracture in 60 patients, (sensitivity 96.8%, 95% CI 92.4–100%). Two fractures were clinically insignificant. If only clinically significant fractures were considered, the instrument had a sensitivity of 100%. The decision instrument predicted, with a high degree of sensitivity, those patients who could safely forgo pelvic radiography after blunt trauma. Approximately 44% of our patient population could have done without a pelvic X-ray, resulting in significant saving of health care dollars. These criteria need to be prospectively validated. © 2005 Elsevier Inc.

Keywords—pelvic trauma; blunt trauma; pelvic radiography; pelvic fracture; fracture diagnosis

INTRODUCTION

The incidence of pelvic fractures in the U.S. is 37 per 100,000 person years (1). Recent studies show these fractures are present in 4.8–7% of blunt mechanism trauma patients presenting to the Emergency Department (ED) (2,3). Pelvic fractures and accompanying injuries are common causes of death in these patients (1). The mortality of patients who sustain pelvic fractures ranges from 5–20%; this number falls if simple pelvic fractures are included (1). Morbidity and mortality associated with pelvic hemorrhage can be prevented with early detection of pelvic fractures. Physical examination alone may be inadequate to detect pelvic fractures; this has led many trauma centers to obtain routine anterior-posterior (A-P) pelvic radiographs as a screening tool for pelvic fractures in patients who present with blunt trauma. Additionally, the American College of Surgeons Advanced Trauma Life Support (ATLS) course recommends obtaining routine A-P pelvic radiographs on all patients who sustain blunt trauma. Additionally, the American College of Surgeons Advanced Trauma Life Support (ATLS) course recommends obtaining routine A-P pelvic radiographs on all patients who sustain blunt trauma. However, the vast majority of these films are negative (2,3).

In previous studies evaluating the need for such radiographs, variables used to identify patients who could safely forgo pelvic radiography differed (2–4). However, certain common threads can be found: physical examination findings, mental status, and presence of intoxication. Additionally, Tien and Dufel, in their retrospective
case-control study, cited distracting injury as the most common cause of a missed fracture (5).

The purpose of this study was to validate a decision instrument to identify a subset of patients who could safely forgo pelvic radiography as part of their initial trauma evaluation. Not only would such an instrument limit patient radiation dose and time spent in initial radiographic evaluation, but considerable cost savings may be realized (3,6).

**METHODS**

This prospective, observational study was conducted at an urban level I trauma center. The ED has an annual census of 50,000 patients, and treats approximately 2500 trauma patients per year. The study was approved by the hospital’s Institutional Review Board and performed under a waiver of informed consent.

The eligible patient population consisted of victims of blunt trauma brought in by Emergency Medical Services (EMS) as “level one traumas.” This designation is based on Arizona Emergency Medical Systems (AEMS) pre-hospital triage guidelines, which closely resemble those put forth by the American College of Surgeons (7,8). Thus, patients ranging from those with no injury (but significant mechanism) to those with life-threatening injuries may be given this designation. Patients were excluded if they had been previously seen at an outside facility for the same injury, if they were less than 18 years old, if they were pregnant, or if no pelvic radiograph was obtained at the time of the initial trauma evaluation. The decision whether or not to obtain a pelvic radiograph was made by the physician caring for the patient. The criteria did not influence that decision.

Upon patient presentation, a data form was completed by an Emergency Medicine resident or attending physician regarding the presence or absence of five criteria: 1) altered level of consciousness (Glasgow Coma Scale [GCS] score <14), 2) complaint of pelvic pain, 3) pelvic tenderness on physical examination, 4) distracting injury, and 5) clinical intoxication. The latter two criteria were judgment based. The form was completed before that physician seeing the A-P pelvic radiograph. The five criteria made up the decision instrument that would predict whether or not a pelvic radiograph should be obtained.

Final radiographic readings were later linked with the criteria data on the data forms. If a pelvic fracture was present, it was classified as clinically significant or non-significant based on theTile classification of pelvic fractures (see Table 1) (9). Class A fractures were non-significant; class B and C were clinically significant.

The sensitivity, specificity, negative predictive value, and negative likelihood ratio were calculated for the instrument. The instrument was said to correctly identify patients who could forgo radiography if no positive criteria were present.

### Table 1. Tile Classification of Pelvic Fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Posterior arch intact, fracture of innominate bone (avulsion)</td>
</tr>
<tr>
<td>A2</td>
<td>Posterior arch intact, fracture of innominate bone (direct blow)</td>
</tr>
<tr>
<td>A3</td>
<td>Posterior arch intact, transverse fracture of sacrum caudal to S2</td>
</tr>
<tr>
<td>B1</td>
<td>External rotation instability, open-book injury, unilateral</td>
</tr>
<tr>
<td>B2</td>
<td>Incomplete disruption of posterior arch, unilateral, internal rotation (lateral compression)</td>
</tr>
<tr>
<td>B3</td>
<td>Incomplete disruption of posterior arch, bilateral</td>
</tr>
<tr>
<td>C1</td>
<td>Complete disruption of posterior arch, unstable</td>
</tr>
<tr>
<td>C2</td>
<td>Bilateral injury, one side rotationally unstable, one side vertically unstable</td>
</tr>
<tr>
<td>C3</td>
<td>Bilateral injury, both sides completely unstable</td>
</tr>
</tbody>
</table>

**RESULTS**

Data were collected from July 2002 through June 2003. There were 2329 level I trauma patients seen, of whom 1199 met enrollment criteria; 973 patients (81%) were captured. Sixty-two had pelvic fractures identified on pelvic radiography, yielding a prevalence of 6.4%.

The instrument failed to predict a fracture in two of these patients (overall sensitivity 96.8%, 95% CI 92.4–100%). The overall negative likelihood ratio was 0.06 (95% CI 0.017–0.23). Neither of the missed fractures was considered clinically significant by the Tile classification (9). Thus, if only clinically significant fractures are considered, the instrument had a sensitivity of 100%, a negative predictive value of 100%, and a negative likelihood ratio approaching 0.

The two fractures missed by the instrument are described as follows. The first fracture was a non-displaced, unilateral superior pubic ramus fracture. This patient was observed overnight for other reasons and discharged with weight bearing as tolerated and no specific orthopedic follow-up needed. The second patient had unilateral superior ramus and non-displaced iliac wing fractures. Although her fracture was classified as clinically insignificant, she was discharged as non-weight bearing and no orthopedic surgical procedure was planned. Upon review of this patient’s chart, it was documented that the patient was perseverating, had multiple right rib fractures with a pneumothorax, and was complaining of lumbar back pain. The decision by the
examiner to classify this patient as “no distracting injury” could be questioned.

If the decision instrument had been used clinically on this population, 434 patients would have forgone radiography (see Table 2). This represents 44.6% (436/973) of study patients. This closely parallels the specificity for the instrument, which was 47.6% (95% CI 44.4–50.9%).

**DISCUSSION**

The utility of routinely obtaining pelvic radiographs on all blunt trauma victims has been previously studied and reported in the literature. Review of these studies, however, indicates mixed results regarding which portions of the evaluation were important in determining which patients could forgo radiography. No study found a “rule” with sensitivity greater than 93%. Additionally, no study examined the difference between clinically significant and insignificant fractures.

In September 2001, Duane reviewed the medical records of all trauma patients over 1 year (3). Duane evaluated initial hemodynamics, physical examination, laboratory findings, and hospital charges. The author concluded that one could predict the absence of pelvic fractures in awake and alert blunt trauma patients with normal hemodynamics and laboratory findings. Although Duane supported selective use of radiography, the rule relied on the results of laboratory findings. In the initial evaluation of the trauma patient, this is not expedient.

Gonzalez reported a prospective study of blunt trauma patients, evaluating the sensitivity of clinical examination as a screening tool for pelvic fractures (2). The study demonstrated a sensitivity of 93%; however, the tool’s criteria were not clearly described.

In 1993, Koury et al. prospectively studied alert, oriented and reliable patients involved in blunt trauma (4). They concluded that these patients do not need routine pelvic radiography if the findings on physical examination are negative. Positive physical findings included pain with palpation or compression of the pelvic girdle, sacroiliac or lower lumbar areas, or pain with hip movement. Salvino et al. concluded the same in their prospective study of 810 patients with GCS ≥ 13 (6). In their study, only 3 of 39 patients had fractures not suspected by complaint or examination. This represents 7.6% of the fractures, however, and may be a higher “miss rate” than most physicians are willing to accept. None of the three fractures altered the clinical course or were considered “significant,” although this was not defined a priori. Additionally, 743 of 771 patients without fracture had no complaint of pain or tenderness on examination. These are patients that could have forgone radiography.

Some authors conclude that routine pelvic radiography is warranted. Gillott et al. recommended pelvic X-ray should be performed routinely in blunt trauma patients as part of the early resuscitation, because a positive finding has immediate prognostic and therapeutic implications (10). Likewise, Kaneriya found protocol-driven pelvic radiography (the trauma protocol required all patients to get a pelvic radiograph) to be cost-effective, but this was based on a retrospective chart review of 319 patients (11).

The cost effectiveness of eliminating unnecessary pelvic radiographs has been shown previously. Duane estimated hospital costs would be reduced by $168,300.00 per year if radiographs were limited at his institution (3). Salvino et al. found it cost $88,000 to diagnose the pelvic fractures described in their study (above) and concluded that routine pelvic radiography is not “cost-effective in the management of awake blunt trauma patients who do not complain of pain and who have normal pelvic physical examination results” (6).

This study demonstrated that 44% of pelvic radiographs could have been safely avoided. The patient charge for a pelvic radiograph at our facility is $212. This translates into a savings of $92,432 over a 1-year period if selective radiography is used. Of course, this figure is based on charges and not reimbursement.

Our decision instrument had an overall sensitivity of 97% and a sensitivity of 100% when only clinically significant fractures were considered. In addition, we could show a significant cost savings if the rule were to be implemented. There are some limitations to the study, however. Primarily, the criteria for the instrument were not prospectively derived in a separate study. Instead, we incorporated the most sensitive indicators from previous studies.

Errors in sensitivity and negative predictive value may occur through biased enrollment. Safety and cost concerns precluded ordering pelvic radiographs on all blunt trauma patients, if some of those patients would otherwise not have had that radiography (based on physician preference). Additionally, this would have required informed consent, which would be impossible to obtain on all patients (e.g., multi-trauma victim with altered level of consciousness). To eliminate this selec-

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**Table 2. Distribution of Patients**

<table>
<thead>
<tr>
<th>Fracture Present</th>
<th>Fracture Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>One or more criteria Present</td>
<td>60</td>
<td>477</td>
</tr>
<tr>
<td>All criteria absent</td>
<td>2*</td>
<td>434</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>911</td>
</tr>
</tbody>
</table>

* Both fractures clinically insignificant.
tion bias, our methodology allowed us to conduct an observational study under a waiver of informed consent. We enrolled all blunt trauma patients who underwent pelvic radiography, including those most likely to have significant pelvic pathology. However, this process introduces the possibility of workup bias. It is possible that a patient with a significant pelvic fracture exhibited none of our study criteria and did not undergo radiographic imaging. This would represent an undetected false-negative event. Our data suggest that this would be a highly unlikely event; the potential for bias is more theoretical than practical. In fact, more likely than not, if enrolled, these patients would have no positive criteria and negative X-rays, thereby increasing the specificity of the instrument.

Errors in sensitivity and negative predictive value could also occur from physicians’ change of answers after radiographic review. By requiring data to be entered before radiographic study, this bias should be eliminated. In those patients whose unstable status precludes documentation of answers before obtaining an X-ray study, the very nature of the injuries that cause the physiologic instability should be sufficient to cause the patient to exhibit criteria (e.g., distracting injury). Any bias from data alteration in this group should be insignificant.

This study incorporates important aspects of the patient presentation and examination seen in previous studies into a decision instrument. We also examined the effect of distinguishing clinically insignificant fractures. The decision instrument was validated on a wide range of blunt trauma injuries. The sensitivity and negative likelihood ratio, especially when applied to solely clinically significant fractures, indicate that the instrument is accurate. Improvements to the instrument (i.e., improving specificity) could be made by further derivation using other aspects of history and physical examination. This decision instrument needs to be validated in a larger patient sample drawn from a variety of ED settings.

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REFERENCES