Accuracy of Trauma Ultrasound in Major Pelvic Injury

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Background: Trauma ultrasound (US) utilizing the focused assessment with sonography in trauma (FAST) is often performed to detect traumatic free peritoneal fluid (FPF). Yet its accuracy is unclear in certain trauma subgroups such as those with major pelvic fractures whose emergent diagnostic and therapeutic needs are unique. We hypothesized that in patients with major pelvic injury (MPI) trauma ultrasound would perform with lower accuracy than has previously been reported.

Methods: Retrospective analysis of adult trauma patients with pelvic fractures seen at an urban Level I emergency department and trauma center. Patients were identified from the institutional trauma registry and ultrasound database from 1999 to 2003. All patients aged >16 years with MPI (Tile classification A2, all type B and C pelvic fractures, and type C acetabular fractures determined by a blinded orthopedic traumatologist) and who had a trauma US performed during the initial emergency department evaluation were included. All ultrasounds were performed by emergency physicians or surgeons using the four-quadrant FAST evaluation. Results of US were compared with one of three reference standards: abdominal/pelvic computed tomography, diagnostic peritoneal tap, or exploratory laparotomy. Two-by-two tables were constructed for diagnostic indices.

Results: In all, 96 patients were eligible; 9 were excluded for indeterminate ultrasound results. Of the remaining 87 patients, the pelvic fracture types were distributed as follows: 9% type A2, 72% type B, 16% type C, and 3% type C acetabular fractures. Overall US sensitivity for detection of FPF was 80.8%, specificity was 86.9%, positive predictive value was 72.4%, and negative predictive value was 91.4%. Categorization of sensitivity according to pelvic ring fracture type is as follows: type A2 fractures: sensitivity and specificity, 75.0%; type B fractures: sensitivity, 73.3%, specificity, 85.1%; and type C fractures (pelvis and acetabulum): sensitivity and specificity, 100%. Of the true-positive US results, blood was the FPF in 16 of 21 (76%) and urine from intraperitoneal bladder rupture in 4 in 21 (19%) patients.

Conclusion: US in the initial evaluation of traumatic peritoneal fluid in major pelvic injury patients has lower sensitivity and specificity than previously reported for blunt trauma patients. Additionally, urerperitoneum comprises a substantial proportion of traumatic free peritoneal fluid in patients with MPI.

Key Words: Ultrasound, Trauma, Intraperitoneal hemorrhage, Pelvic fracture, FAST.


Ultrasound (US) has been shown to be an accurate diagnostic test in the setting of blunt abdominal trauma for detecting clinically significant hemoperitoneum with sensitivity of 72% to 93% and specificity of 90% to 100%. Although the accuracy of abdominal ultrasound for free peritoneal fluid (FPF) in patients with major pelvic injury (MPI) is not known, previous reports have suggested that the presence of pelvic injury creates potential difficulties with the use of ultrasound for diagnosis and management of blunt abdominal trauma. Distortion of the bony pelvis and its associated vascular structures change the architecture of the pelvis and retroperitoneum and theoretically impact the utility of previous usally accepted diagnostic modalities such as ultrasound. The hypothesis of the present study states that ultrasound would perform with a lower sensitivity and specificity in patients with MPI compared with established values in a general trauma population.

PATIENTS AND METHODS

This study was a retrospective analysis of all trauma patients aged >16 years at an urban regional Level I trauma center with an annual emergency department volume of greater than 100,000 patients/year and approximately 1,900 trauma admissions per year. The standard initial evaluation of patients at our institution with multiple trauma or suspected intra-abdominal or pelvic injuries include chest radiography, pelvic radiography, and four-quadrant trauma ultrasound, also known as the Focused Assessment with Sonography in Trauma (FAST). FAST examinations are performed by either attending or resident physicians from the emergency medicine or trauma surgery service. All resident US are supervised by credentialed attending physicians from one of the services. As a part of routine care, trauma ultrasound are interpreted in real time as positive (presence of anechoic collection in known dependent peritoneal or pericardial space), negative, or indeterminate. All ultrasounds performed undergo quality assurance review for image quality and in-
terpretation and are logged in an institutional ultrasound database.

The trauma registry, which contains standard information on all institutional trauma patients including demographics, mechanism of injury, all diagnostic tests performed, hospital course and discharge diagnosis, and procedure codes compiled by one of two data analysts, was searched for all patients with pelvic fractures during the period March 1999 to May 2003. The radiographs of these patients were reviewed by one attending orthopedic traumatologist for the presence of MPI as defined by the classification described by Tile.8 The following Tile subtypes were considered major injuries: A2, direct injury to innominate bone or anterior pelvic arch; B, rotational unstable pelvic injuries; C, completely unstable pelvic ring injuries; and C acetabular fractures-associated bone column acetabular fractures (Fig. 1).

The patients with MPI were cross-referenced to the institutional US database and those patients with US logged were included in the study. Patients were excluded for indeterminate ultrasound results (as interpreted by the clinician at the time the ultrasound was performed). All US results were confirmed by one of three methods: abdominal/pelvic CT, diagnostic peritoneal tap (DPT), or exploratory laparotomy. In addition to pelvic injury and US data, demographics, mechanism of injury, disposition, and length of stay were obtained. The data were analyzed using descriptive statistics including percentages and means with standard deviations; two-by-two tables were constructed for US diagnostic performance.

**RESULTS**

A total of 96 patients were identified, 9 of which were excluded for indeterminate ultrasound results, leaving a study population of 87 patients. The average age was 42 ± 19.4 years with 55% male. The mechanism of injury included motor vehicle collision 57%, pedestrian struck 6%, motorcycle collision 5%, fall from height 4%, and crush injury 2%

The pelvic fracture types according to the Tile classification were type A2 9%, type B1 7%, type B2 58%, type B3 7%, type C 16%, and type C acetabular 3%.

US was performed for detection of FPF with a sensitivity of 80.8% (95% CI 65.6% to 95.9%) and a specificity of 86.9% (CI 78.4% to 95.4%) as is shown in Table 1. When subcategorized according to Tile fracture type, the sensitivities and specificities for free peritoneal fluid are as follows:

<table>
<thead>
<tr>
<th>Tile Subtype</th>
<th>Sensitivity (95% CI)</th>
<th>Specificity (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2 Fractures</td>
<td>75.0% (19.4% to 99.4%)</td>
<td>75.0% (19.4% to 99.4%)</td>
</tr>
<tr>
<td>B Fractures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Fractures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C Acetabular</td>
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**Table 1** Overall Sensitivity and Specificity of Trauma US in Major Pelvic Injury

<table>
<thead>
<tr>
<th>Confirmatory Test</th>
<th>Positive</th>
<th>Negative</th>
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<tbody>
<tr>
<td>US Positive</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>US Negative</td>
<td>5</td>
<td>53</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>61</td>
</tr>
</tbody>
</table>

Sensitivity (21/26) = 81% (95% CI 66–96); Specificity (53/61) = 61% (95% CI 78–85); PPV (21/29) = 72% (95% CI 56–89); NPV (53/58) = 91% (95% CI 84–99).
sensitivity 73.3% (CI 51% to 95%) and specificity 85.1% (CI 74.9% to 95.3%); and type C fractures: sensitivity 100% (CI 65.2% to 100%) and specificity 100% (CI 74.1% to 100%). Of the true-positive US results, blood was the FFP in 16 of 21 (76%), and urine from intraperitoneal bladder rupture in 4 of 21 (19%) patients.

Of the eight false-negative ultrasound exams for FFP, three of eight (38%) had extensive pelvic hematomas, two of eight (25%) had extraperitoneal bladder rupture (one with simultaneous pelvic hematoma), and four of eight had no fluid seen on computed tomography. Of the false negatives for FFP, three patients had splenic lacerations, one had a liver laceration, and one had hemoperitoneum of unknown source. All false-negative ultrasound patients had small collections of FFP.

Of the four patients with uroperitoneum, one patient was hemodynamically unstable in the emergency department (ED) with transfer to the operating room (OR) with only a bladder rupture found at emergent laparotomy. This patient underwent immediate angiographic embolization and stabilization subsequent to the OR. The other three uroperitoneum patients with positive FAST examinations in the ED had stable hemodynamics with computerized tomography, angiography, and laparotomy (in that order).

**DISCUSSION**

Ultrasound has become an accepted initial diagnostic procedure for the detection of hemoperitoneum in trauma patients in the United States during the last decade because of its rapid, noninvasive, portable, nonionizing, and accurate diagnostic ability. Most emergency medicine training programs as well as Level I trauma centers report having adopted ultrasound for the evaluation of the blunt trauma patient. With the increased use of ultrasound, many new issues have arisen regarding management of specific trauma patient subtypes.

Pelvic fractures, seen in 9% of blunt abdominal trauma victims, are associated with a mortality rate approaching 50% in hemodynamically unstable patients; in addition, the mortality correlates with fracture severity. The injuries in the pelvic trauma patient may not only be the typical abdominal solid organ injuries but may also include retroperitoneal vascular structures. The evaluation for intraperitoneal injury in the patient with blunt abdominal trauma and a simultaneous significant pelvic fracture often requires complicated decision-making and emergent actions. Bleeding within the abdomen usually demands surgical management; however, simultaneous exsanguinating retroperitoneal bleeding requires angiography and embolization. The decision in the emergency department on how and where to proceed with the patient for therapeutic intervention is critical in dictating the proper sequence of therapeutic intervention and the ultimate survival of the multitrauma patient with a significant pelvic fracture.

Our data showed an overall sensitivity and specificity of US in MPI of 81% and 87%, respectively, which are lower than the generally accepted diagnostic abilities of US documented in previous prospective studies of general trauma populations with sensitivities in the 90% to 100% range and specificities in the 97% to 99% range. We theorize that our lower specificity may be a result of the anatomic distortions in the retroperitoneum of patients with MPI from both fracture displacement and hematoma formation, resulting in hypoechoic to anechoic collections that may mimic true peritoneal fluid. Additionally, with seepage of retroperitoneal hematomas, some fluid collections can occur within the peritoneum that may not have true surgical significance.

When examining the data for ultrasound performance by fracture type, we found that the highest sensitivity and specificity was in the subgroup with the most severe fractures (Tile type C). Although we must be cautious because of the overall small patient numbers, this high sensitivity is encouraging for the sickest of blunt abdominal and pelvic fracture patients that may require emergent orthopedic stabilization, angiographic embolization, and possible laparotomy.

The management of the patient with free peritoneal fluid on trauma ultrasound has usually been stratified by hemodynamic stability. Those patients with sonographic free peritoneal fluid who are clinically stable receive computerized tomography of the abdomen and pelvis for delineation of potential injuries. Those with sonographic free peritoneal fluid who are persistently unstable, however, usually receive an emergent laparotomy. However, in the unstable trauma patient with a major pelvic injury, the possibility of significant blood loss in the retroperitoneum may require a different therapeutic intervention based on the nature of the concomitant peritoneal injuries. Peritoneal blood would suggest hemodynamic compromise from an immediately correctable solid organ or vascular injury, whereas urine (or bile) suggests an injury requiring delayed therapeutic laparotomy and immediate consideration of pelvic hemorrhage requiring embolization.

Other reports have documented the presence of uroperitoneum in the presence of pelvic fracture in the blunt abdominal trauma victim. It is known that between 4% and 8% of patients with pelvic fractures have an associated bladder injury. In our study, uroperitoneum comprised an important proportion of traumatic free peritoneal fluid (19%). This is important because uroperitoneum may be mistaken for hemoperitoneum, prompting a nonemergent therapeutic laparotomy in an unstable patient. Although uroperitoneum represents a true-positive finding on US, it may lead the clinicians to employ the wrong sequence of therapeutic interventions, as occurred in one of our uroperitoneum patients and two patients in our previous series. The presence of uroperitoneum, although mandating therapeutic laparotomy, may not supersede the need for emergent pelvic embolization therapy to reduce life-threatening hemorrhage from disrupted pelvic vessels.

We provide a suggested algorithm (Fig. 2) for the use of ultrasound in the unstable blunt abdominal trauma victim with a positive FAST examination for peritoneal fluid and a major pelvic fracture. We incorporate a diagnostic peritoneal
tap (aspirate), which will separate hemoperitoneum (suggesting immediate laparotomy) from uroperitonum (suggesting retroperitoneal vascular exsanguination requiring immediate embolization therapy and a delayed laparotomy).

The peritoneal sampling only requires an aspirate and not necessarily a lavage as the information required is the type of peritoneal fluid, not the concentrations in lavage fluid. In addition, ultrasound may be used to guide the needle aspirate around adjacent bowel. DPT done supraumbilically with a Seldinger technique done within 5 minutes is preferable to a minilaparotomy, in our experience, because of the performance time and delay for transport and induction for any OR procedure or even an open diagnostic peritoneal incision in the ED to visualize the peritoneum, which would take typically 10 to 15 minutes. This sampling of peritoneal fluid, in our opinion, is worth the few minutes to direct the patient to the correct sequence of therapy.

Although some would advocate the avoidance of trauma ultrasound in the unstable trauma patient with a pelvic fracture, we would comment that the performance of trauma ultrasound is routinely faster and less complicated than any diagnostic peritoneal aspirate or lavage, which may have to be altered to a supraumbilical approach in the pelvic fracture patient. In addition, alteration of typical protocol utilizing the FAST examination may lead to inappropriate diagnostic delays for those trauma patients whose injuries do not fit this clinical situation.

**Limitations**

This report has several important limitations that require discussion. First, this is a single-center, retrospective analysis subject to incorporation bias, selection bias, and potentially missed cases of pelvic injury. In addition, the results of this study are limited because of the small sample size and the relatively small number of each subtype of pelvic injury.

**CONCLUSION**

In the initial evaluation of traumatic peritoneal fluid in patients with major pelvic injuries, ultrasound has a lower sensitivity and specificity than previously reported for blunt trauma patients. Uroperitoneum appears to comprise a substantial proportion of traumatic free peritoneal fluid in this patient population. Further prospective evaluation is needed to determine the appropriate role of ultrasound in the initial management of patients with major pelvic trauma.

**REFERENCES**