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The Effectiveness of Focused Assessment With Sonography for Trauma in Evaluating Blunt Abdominal Trauma With a Seatbelt Mark Sign

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Abstract

Background: Specific injury patterns have been recognized from seatbelt use including hollow viscous, mesenteric, and musculoskeletal injuries. We aimed to evaluate if focused assessment with sonography for trauma (FAST) is a reliable screening tool for the initial evaluation of the blunt abdominal trauma patient with a seatbelt sign.

Methods: A retrospective review of adult trauma patients with blunt abdominal trauma and a positive seatbelt sign were evaluated over a three-year period. Data collected included age, gender, Glasgow coma scale (GCS), presence or absence of abdominal tenderness, results of diagnostic studies, operative findings, missed injuries, and mortality.

Results: A total of sixty-nine patients were evaluated. Fifty-eight ultrasound scans were interpreted as negative and 11 positive. Three of the 11 were taken immediately to the operating room. The remaining 8 underwent computerized tomography (CT) according to protocol and clinical management was altered in two. Sixteen patients with a negative ultrasound examination underwent CT. Our series revealed 11 true and no false positives, as well as 54 true and 4 false negatives. The sensitivity of utilizing FAST for detecting a clinically significant injury in this study is 73% with 100% specificity, a negative predictive value of 93%, positive predictive value of 100%, and accuracy of 94%.

Conclusions: The use of FAST, not as a single diagnostic modality, but as a screening tool with selective use of CT, is a relatively reliable instrument for the initial evaluation of the blunt abdominal trauma patient with a seatbelt mark sign.

Keywords: Blunt abdominal trauma; Seatbelt sign; Computed tomography; Sonography; Screening; Fast; Sensitivity; Specificity

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Introduction

Three distinct forces occur during a motor vehicle collision. The first is the force of the automobile colliding with another object. The second is the force of the unrestrained occupant colliding with the interior of the vehicle. The third is the force of the internal organs colliding against the body's musculoskeletal structures, which often results in serious or fatal injuries.

A seatbelt functions to stop the occupant with the automobile, preventing the body from continuing to travel at the vehicle's primary speed after it has stopped, thus eliminating the second force of a vehicular collision. The properly worn safety belt is designed to spread the rapid deceleration energy over the larger and stronger parts of the body; namely the pelvis, chest, and shoulders.

The protective effect of safety belts in reducing morbidity and mortality from vehicular accidents has resulted in widespread legislation mandating their use. Seatbelts have decreased both the overall fatality rate in motor vehicle collisions as well as the severity of non-fatal moderate to critical injuries [1, 2].

Although seatbelts greatly decrease the associated morbidity and mortality of automobile collisions, specific injury patterns have been recognized as arising directly from their intended use including hollow viscous, mesenteric, and musculoskeletal injuries [3-6]. Seatbelt related injuries are the result of the altered physics of rapid deceleration caused by restraint with the lap belt and shoulder harness. Injury from seatbelts, and the associated seatbelt syndrome, was first introduced by Garrett and Braunstein in 1962 in which they described a variety of injuries associated with the lap belt restraint [7]. An abdominal seatbelt mark sign is classically described as abdominal wall contusions and abrasions resulting

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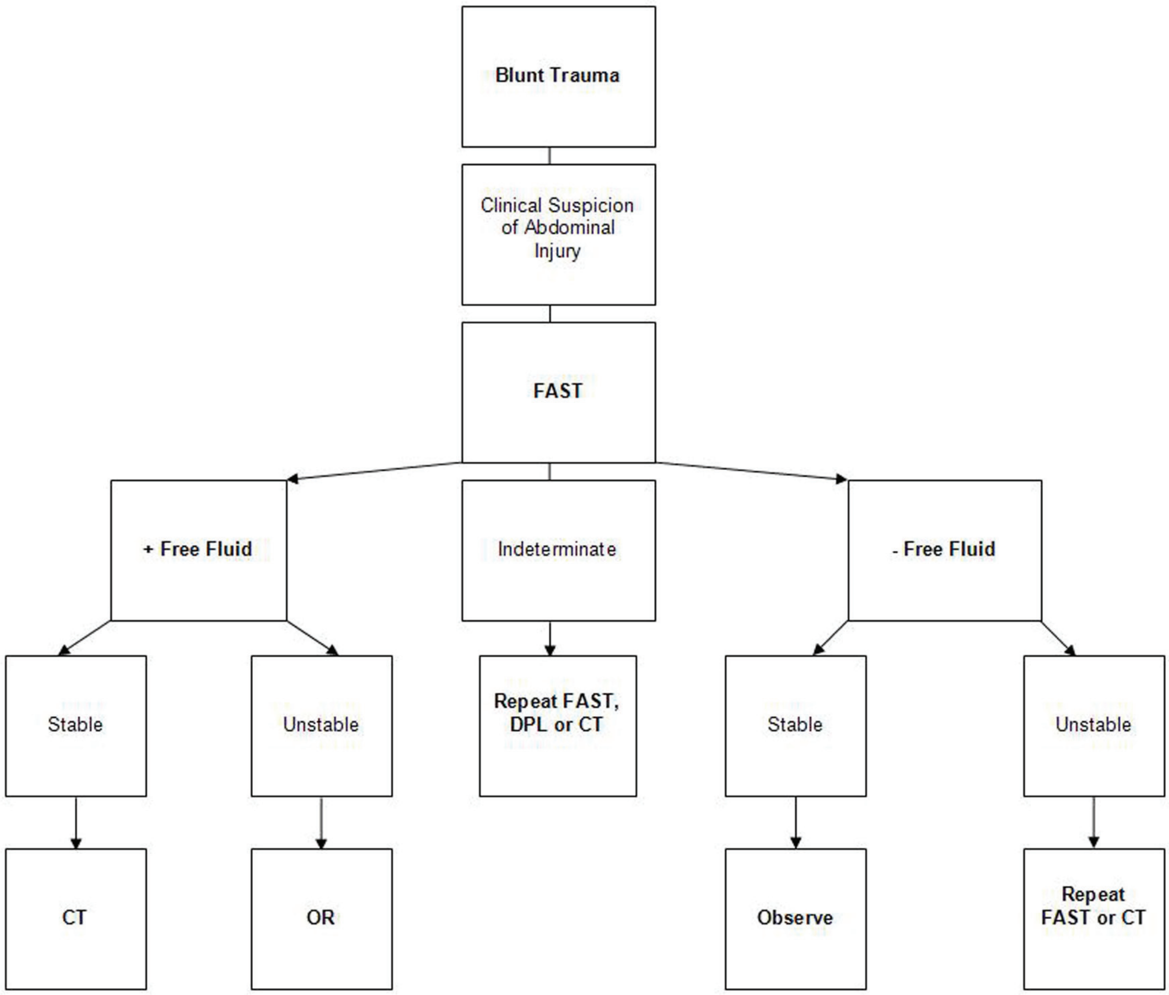

Figure 1. FAST based algorithm.

from a seat restraint. Seatbelt syndrome consists of a seatbelt mark sign as well as the underlying mesenteric, visceral, and musculoskeletal injuries.

The University of Kentucky trauma service began using ultrasound scans in 1996 as a screening tool for the evaluation of trauma patients. Prior to that time all patients requiring objective non-operative evaluation of the abdomen received a computerized tomography (CT) scan or underwent diagnostic peritoneal lavage (DPL). After instituting a focused assessment with sonography for trauma (FAST) screening algorithm (Fig. 1) CT was used more selectively and DPL was rarely utilized. Most blunt abdominal trauma patients seen at the University of Kentucky with a seatbelt sign are evaluated using an ultrasound based protocol. A study conducted at the University of Louisville concluded that FAST is an unreliable method for assessing intraabdominal injury in patients with seatbelt marks [8]. We aimed to evaluate our hypothesis that the use of FAST, not as a single diagnostic modality, but as a screening tool with selective use of CT, is a relatively reliable instrument for the initial evaluation of the blunt abdominal trauma patient with a seatbelt sign.

Methods

After obtaining approval from the University of Kentucky Institutional Review Board (IRB), a retrospective review of adult trauma patients (≥ 18 years of age) with blunt abdominal trauma and a positive seatbelt sign were evaluated by the trauma service at the University of Kentucky over a three-year period. Data collected included age, gender, Glasgow coma scale (GCS), presence or absence of abdominal tenderness, results of diagnostic studies (ultrasonography and CT), operative findings, missed injuries, and mortality. All ethical guidelines for conducting human studies were followed according to to the University of Kentucky IRB.

Ultrasound scans were performed in a standard manner and interpreted by the attending trauma surgeon and/or fel-

Table 1. True Positive Results

FAST	GCS	ABD Tenderness	CT Results	OR Findings
Positive	15	YES	N/A	Mesenteric laceration of small bowel and colon
Positive	15	YES	N/A	Small bowel mesenteric laceration and minor liver laceration
Positive	15	YES	N/A	Multiple small bowel mesenteric lacerations and small splenic laceration
Positive	14	YES	Free air, fluid in pelvis	Jejunal perforation and sigmoid colon seroral injury
Positive	15	YES	Free fluid without solid organ injury	Grade I liver laceration
Positive	15	YES	Grade II splenic laceration, free fluid	N/A
Positive	15	NO	Ascites secondary to cirrhosis	N/A
Positive	15	YES	Rt kidney laceration and small liver laceration	N/A
Positive	15	NO	Grade II liver laceration and pancreatic head contusion	N/A
Positive	15	YES	Grade III splenic laceration	N/A
Positive	15	YES	Subcutaneous air, fluid in Morrison's space	N/A

low. Evaluation included pericardial, hepatorenal, splenorenal, and suprapubic images. Results were interpreted as positive if free fluid was present in one or more of the viewable areas evaluated and negative in the absence of free fluid. If a definitive interpretation could not be made the result was recorded as indeterminate. FAST imaging was carried out using a Philips ATL 3,500 machine with a variable frequency transducer (Philips Medical Systems, Bothell, WA).

For the subset of patients requiring CT as part of their assessment, an abdominal and pelvic CT scan was performed after administration of oral and IV contrast using a Siemens multislice CT scanner (Siemens Medical Systems, Malvern, PA). Staff radiologists along with either the attending trauma surgeon and/or fellow interpreted the CT scan results.

Results

At total of one hundred and three blunt abdominal trauma patients who presented with a seatbelt sign were evaluated. Thirty-four were excluded (16 less than eighteen years of age, 6 transferred to our facility after CT was performed, 8 evaluated with CT only, 4 evaluated with observation alone) leaving an aggregate of 69 patients who received FAST as part of their initial evaluation.

Of the 69 patients included in our study the average age of our patient population was 46.6 (range 18-80) with a nearly equal number of females (n = 35) and males (n = 34). Most were neurologically intact with sixty-two (90%) presenting with a GCS of 15, four (6%) with a GCS of 14, and one each (1%) with a GCS of 13, 12, and 3T. Abdominal tenderness was noted in a total of 44 (64%) patients. Two (3%) patients died, both secondary to multiorgan system failure. One (80 years old) presented with a GCS of 3T and the second (79 years old) presented with a GSC of 15. Both had negative FAST exams, did not undergo subsequent abdominopelvic CT scanning, and neither were operated on. The remaining 67 patients (97%) were all eventually discharged from the hospital.

Fifty-eight (84%) ultrasound scans were interpreted as

Table 2. False Negative Results

FAST	GCS	ABD Tenderness	CT Results	OR Findings
Negative	15	NO	Grade III splenic laceration	N/A
Negative	15	NO	Grade IV splenic laceration	N/A
Negative	15	YES	Fluid/stranding in pelvis	Multiple mesenteric lacerations and serosal tears (all sigmoid)
Negative	15	YES	Small bowel injury	Jejunal perforation and colonic serosal tears

negative and 11 (16%) positive. We did not have any indeterminate examinations. Three of the 11 interpreted as positive were taken immediately to the operating room for instability, with all having mesenteric or gastrointestinal tract injuries requiring resection. The remaining 8 stable patients underwent CT (within 15 to 140 minutes) according to protocol and clinical management was altered based on the CT findings in two. Both underwent exploratory laparotomy with a grade 1 liver laceration found in one and a jejunal perforation and sigmoid serosal injury in the other (Table 1). Sixteen of the 58 patients with a negative ultrasound examination underwent a CT scan (within 15 minutes to 13 hours) secondary to abdominal pain (11) or instability (5), of which 12 were negative for intraabdominal injury. Two splenic injuries lacking abdominal pain were treated non-operatively, one colonic serosal tear and jejunal perforation with associated abdominal pain required repair, and one with multiple sigmoid mesenteric lacerations and serosal tears coupled with abdominal pain required operative intervention (Table 2). Our series revealed 11 true and no false positives, as well as 54 true and 4 false negatives. The sensitivity of utilizing FAST for detecting a clinically significant injury in this study is 73% with 100% specificity, a negative predictive value of 93%, positive predictive value of 100%, and accuracy of 94%.

Discussion

In the critically injured patient accurate diagnosis and prompt treatment of life-threatening injuries are crucial to survival. Other than physical examination different investigative modalities such as DPL, CT, and ultrasonography can be utilized in the evaluation of the blunt abdominal trauma patient with a seatbelt mark sign. Physical examination alone can be subtle and unreliable in a polytrauma patient and has been shown to be relatively poor for diagnosing intraabdominal injury [9].

DPL, although not performed in our study, is rapid, inexpensive, can be performed at the bedside and utilized in hemodynamically unstable patients, and is relatively safe. DPL has an overall sensitivity of 98%, specificity of 98%, and diagnostic accuracy close to 100% [10]. Criteria specifically designed to help aid in the diagnosis of hollow viscus injuries utilizing fluid measurements of amylase, alkaline phosphatase, and white blood cell to red blood cell ratios have shown high diagnostic sensitivity and specificity [11, 12]. DPL is an invasive exam, does not identify the cause of hemoperitoneum, and a positive study may lead to a non-therapeutic exploratory laparotomy [13].

In the hemodynamically stable patient abdominal and pelvic CT is useful for evaluating both intra and extraperitoneal (retroperitoneum, thoracic, pelvic) injuries. CT has an overall sensitivity of 96%, specificity of 98%, and accuracy of 97% [14]. CT findings consistent with hollow viscus and mesenteric injuries after blunt abdominal trauma include free fluid, extraluminal air, bowel wall thickening/discontinuity, mesenteric hematoma/streaking, and extravasation of oral contrast [15, 16]. In blunt abdominal trauma CT has a sensitivity of 94% for detecting bowel injury and 96% for identifying mesenteric injuries [17]. CT is time consuming, expensive, has limited applicability in hemodynamically unstable patients, and with the addition of contrast can increase the risk of allergic reactions and aspiration.

Ultrasound scans can detect as little as 100 mL of fluid in the peritoneal cavity, and thus are useful in detecting the presence of intraperitoneal hemorrhage/fluid. FAST has an overall sensitivity of 76-100% and specificity of 96-100% [18, 19]. Compared to other diagnostic studies employed in trauma, such as DPL and CT, advantages of utilizing ultrasonography include its safety, rapid results, lower costs, performance at the bedside especially in hemodynamically unstable patients, and its noninvasive nature [20]. Unstable patients with evidence of intraabdominal hemorrhage/fluid can be taken directly to the operating room without delay. Although the sensitivity of FAST for the detection of free intraperitoneal fluid remains high, only 40-50% of bowel injuries are typically identified [21]. Ultrasound scans are less sensitive for hollow viscus and organ specific injuries, operator dependent (accuracy improves with experience), and projects decreased image quality in obese patients.

In an effort to conserve resources while maximizing patient safety we have employed a combined diagnostic modality utilizing FAST and CT of the abdomen and pelvis in virtually all blunt abdominal trauma patients, including those with a seatbelt mark sign. FAST has been shown to be less sensitive for the detection of gastrointestinal tract injuries, and a seatbelt sign alone increases the incidence of hollow viscus injury by as much as 10% [22, 23]. With evidence that the presence of a seatbelt mark sign increases the incidence of hollow viscus injuries we felt compelled to retrospectively investigate our own blunt abdominal trauma patient population with a seatbelt sign.

In our series of 69 patients we have a total of 11 true positive, 54 true negative, and 4 false negative results. None of FAST exams performed in our study were interpreted as indeterminate. Patients with an indeterminate FAST are admitted for observation, serial abdominal examinations, and repeat FAST or completion of a CT or DPL.

Instead of performing an abdominal and pelvic CT scan in all patients with a negative FAST exam we chose to follow them clinically as outlined in our algorithm. Other than two deaths, the remaining 67 patients were all eventually discharged from the hospital. While the FAST exam was falsely negative in four patients, there were no missed injuries utilizing a combined modality of an initial ultrasound scan reinforced by CT. The sensitivity for utilizing FAST for detecting a clinically significant injury in this study is 73% with 100% specificity, a negative predictive value of 93%, positive predictive value of 100%, and accuracy of 94%.

With an initial negative FAST our algorithm calls for repeating an ultrasound scan with a change in the patient's examination (drop in hemoglobin, abdominal pain, nausea and emesis, etc.). Unfortunately these are carried out at the bedside (outside of the trauma bay) and results are infrequently recorded, limiting our ability to adequately evaluate and discuss further in this paper. The applicability of our study to the neurologically impaired patient population is hindered since 90% of our series presented with a GCS of 15. Other limitations to this study include its retrospective nature, a single institution experience, and small patient population.

Conclusion

In conclusion the use of FAST, not as a single diagnostic modality, but as a screening tool with selective use of CT, is a relatively reliable instrument for the initial evaluation of the blunt abdominal trauma patient with a seatbelt mark sign.

Financial Disclosure

No financial support was received.

Abbreviations

FAST: focused assessment with sonography for trauma; GCS: Glasgow coma scale; CT: computerized tomography; DPL: diagnostic peritoneal lavage; IRB: Institutional Review Board

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