

Accuracy of the FAST Exam: A Retrospective Analysis of Blunt Abdominal Trauma Patients

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Abstract

Background: Point-of-care ultrasound (POCUS) is a vital tool for diagnosis and management of emergency room patients. Focused assessment with sonography for trauma (FAST) is a bedside ultrasound performed by clinicians in the evaluation of trauma patients. In 2012, Harborview Medical Center, the only level-one trauma center in five northwestern states, officially incorporated emergency physician (EP) performed FAST exams for critically injured blunt abdominal trauma (BAT) patients.

Objective: We sought to determine the accuracy of EP performed FAST exams for severely injured patients with blunt abdominal trauma (BAT). Secondary objectives included trends in use of diagnostic peritoneal lavage (DPL) to identify hemoperitoneum after the implementation of the new protocol.

Design: We conducted a retrospective chart review using the emergency department tracking system to identify all Emergency Severity Index (ESI) 1 trauma patients with BAT over a 26-month study period (July 1, 2011 to August 31, 2013). Hemodynamically unstable BAT patients who had a FAST exam performed were included for further analysis. Results of EP FAST exams and radiology department FAST exams were compared against peritoneal fluid analysis, computed tomography results, and operative findings, where available.

Results: 185 patients met inclusion criteria. In total there were 33 true positive, 109 true negative, 2 false positive, 12 false negative, and 29 indeterminate examinations, for an overall sensitivity, specificity, and accuracy of 73%, 98%, and 91% respectively. EP performed FAST exams had a sensitivity, specificity and accuracy of 88% (95% CI 67 to 96 %), 98% (95% CI 87 to 99 %), and 94% for moderate to large amounts of intra-peritoneal hemorrhage. The overall use of DPL in the evaluation of critically ill blunt trauma patient decreased slightly with the protocol change, however this decrease was not significant ($p=0.17$).

Conclusion: Our study demonstrated that emergency physicians are accurate in identifying hemoperitoneum in critically injured BAT patients. Secondary findings suggest that utilization of DPL in hemodynamically unstable BAT patients decreased modestly.

Keywords: Abdominal trauma; Ultrasonography; Emergency medicine; Hemoperitoneum

Introduction

In the United States, trauma accounts for 37 million emergency room visits annually and is the leading cause of death in persons younger than 45 years old [1]. Five million cases of blunt abdominal trauma (BAT) occur each year, and 50,000 deaths occur annually because of blunt injury [2]. Early recognition of severe abdominal injury is paramount, as the rapid identification of hemoperitoneum expedites patient care to the operating room for exploratory laparotomy and definitive management. The traditional diagnostic tool for identification of hemoperitoneum has been the diagnostic peritoneal lavage (DPL). Over the last 30 years, bedside ultrasound has been used with increasing frequency to assess for intra-peritoneal hemorrhage [3-7]. Focused Assessment with Sonography for Trauma (FAST) utilizes clinician-performed ultrasonography at the patient's bedside to rapidly identify the presence of hemoperitoneum or hemopericardium associated with acute life threatening injuries. Current literature has demonstrated improved outcomes and shortened time to operative intervention when this examination is performed by trained personnel and included in the initial evaluation of the unstable trauma patient [8,9]. Point of care ultrasound (POCUS) is defined as a focused, goal-oriented bedside ultrasound examination performed by the treating physician to answer a specific question or guide an invasive procedure. POCUS is performed by physicians of various specialties such as emergency medicine, intensive care, and various surgical specialties.

The archetypal POCUS examination, the FAST, was initially developed by emergency physicians (EP) and surgeons caring for traumatically injured patients, and over the past 20 years the number of applications and types of specialists using bedside ultrasound has grown [10,11]. On August 1st 2012, Harborview Medical Center, a large inner-city hospital and training site for the University of Washington, formally incorporated EP-performed FAST exams for the initial evaluation of severely injured BAT patients. Prior to this date, unstable BAT patients received either a FAST exam or a DPL as the initial diagnostic evaluation for hemo-peritoneum. The FAST exam was performed either by a radiologist or emergency physician and interpreted in real time by the performing physician, while the DPL was performed by a general surgeon. After the protocol change, the FAST exam became the first method of investigation, with the DPL reserved for patients with a negative FAST and ongoing hemodynamic instability. We sought

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to evaluate the accuracy of EP FAST exams for unstable BAT patients. Secondary analysis included determination of the trends in use for DPL for unstable BAT patients.

Methods

Study design

We conducted a retrospective analysis of all Emergency Severity Index (ESI) level 1 trauma patients at Harborview Medical Center using the Emergency Department electronic tracking system over a 26-month period (July 1, 2011 to August 31, 2013), thirteen months before and after the protocol change. Patient inclusion criteria were: blunt thoracoabdominal injury, full trauma team activation, and a FAST examination performed as part of the initial diagnostic evaluation. The criterion for full trauma team activation is hemodynamic instability, as demonstrated by hypotension (systolic blood pressure <90 mm Hg), need for cardiopulmonary resuscitation, obvious major vascular injury or need for ongoing transfusion of blood products to maintain blood pressure, as determined by the trauma team. Patients with penetrating injury, no FAST exam, no confirmatory computed tomography (CT) or laparotomy, or who were transferred from an outside hospital with CT imaging of the abdomen already performed, were excluded from analysis. Data was collected using a closed-ended abstraction form for demographics, results of the FAST exam, peritoneal fluid aspirate or lavage, CT, and operative findings when available. FAST exam results were noted to be positive, negative, or indeterminate per the medical record. Indeterminate FAST exams were excluded from determining test characteristics. DPL results were positive if there were greater than 100,000 cells/mm³ red blood cells, 500 white blood cells/mm, elevated amylase, bile or the presence of fibrous material. The primary endpoint was the presence of any amount of intra-peritoneal hemorrhage on CT, or intra-peritoneal hemorrhage identified in the operating room. Inter-rater reliability was determined by comparing FAST results to CT or laparotomy findings using a weighted kappa score. The study was approved by the University of Washington institutional review board.

Setting

Harborview Medical Center is the only designated level 1 trauma center in a five-state region in the Pacific Northwest that includes Washington, Wyoming, Idaho, Alaska, and Montana, with an annual Emergency Department census of over 75,000 patients per year. It serves as the regional referral hospital for a large portion of the Pacific Northwest, and is the primary training site for physicians of various specialties including radiology, trauma surgery and emergency medicine.

Results

A total of 667 ESI level 1 BAT patients were identified using the ED electronic tracking system (Figure 1). 249 patients had full trauma activation, and 185 (74%) unstable BAT patients had a FAST examination performed as part of their initial evaluation with a confirmatory test for comparison. A total of 71/185 (38%) patients also had DPL performed in conjunction with the FAST exam to identify or confirm hemoperitoneum in critically unstable BAT patients. Most patients had full trauma team activation for hypotension and were injured in a motor vehicle collision (Table 1).

Emergency physician FAST

90 FAST examinations were performed by EPs for unstable BAT patients in whom a confirmatory CT or operative report was available.

Gender (%)	
Male	72
Female	28
Age (%)	
<30 years	34
30-60 years	38
>60	28
Mechanism (%)	
Motor Vehicle Collision	42
Motorcycle Accident	18
Pedestrian Struck	14
Fall	11
Other	15
Criteria for Activation (%)	
Hypotension	79
CPR	10
Other	10

Table 1: Patient Demographics.

There were 23/90 positive, 53/90 negative, and 13/90 indeterminate EP FAST exams. There were 22 true positive, 46 true negative, 1 false positive, and 7 false negative examinations for a sensitivity, specificity and accuracy of 76% (95% CI 56 to 89 %), 98% (95% CI 87 to 99 %), and 89% for any amount of free intra-peritoneal hemorrhage (Table 2). The one false positive EP FAST had a normal DPL, no CT findings of intra-peritoneal hemorrhage, and did not require operative management. Of the seven false negative exams, four had trace or small amounts of intra-peritoneal hemorrhage. Three had moderate to large amounts of hemorrhage found on laparotomy, two of which were post-angiography with embolization (Table 3). 6/7 false negatives had associated pelvic fractures. Excluding cases of trace or small fluid collections would have increased the EP FAST sensitivity to 88% (95% CI 67 to 96 %). Of the indeterminate FAST exams, one case was notable for moderate amount of hemo-peritoneum diagnosed by CT not requiring operative management. All other indeterminate EP FAST exams had no intra-peritoneal hemorrhage.

Radiology FAST

Of the 95 FAST exams performed by the Department of Radiology, there were 12 positive, 68 negative, and 16 indeterminate examinations. There were 11 true positive, 63 true negative, 1 false positive, and 5 false negative FAST exams for a sensitivity, specificity and accuracy of 69% (95% CI 41 to 87 %), 98% (95% CI 90 to 99 %), and 93% for any amount of free intra-peritoneal hemorrhage (Table 4). The lone false positive case was followed by a negative DPL, a CT without evidence of free intra-peritoneal hemorrhage and no operative management. All 5 false negative exams were associated with trace or small amount of hemorrhage, and none required an exploratory laparotomy. 3/5 false negative radiology FAST exams were associated with pelvic fractures, and two required angiography guided embolization (Table 5). Excluding cases of trace or small hemorrhage would have increased the sensitivity of the radiology FAST exam to 100%. Of the indeterminate radiology FAST examinations, four were ultimately positive for internal hemorrhage, three of which had moderate to large amounts of blood on laparotomy.

Accuracy of FAST

Of the 185 FAST exams performed collectively, there were 33 true positive, 109 true negative, 2 false positive, 12 false negative, and 29 indeterminate FAST examinations. The sensitivity, specificity and

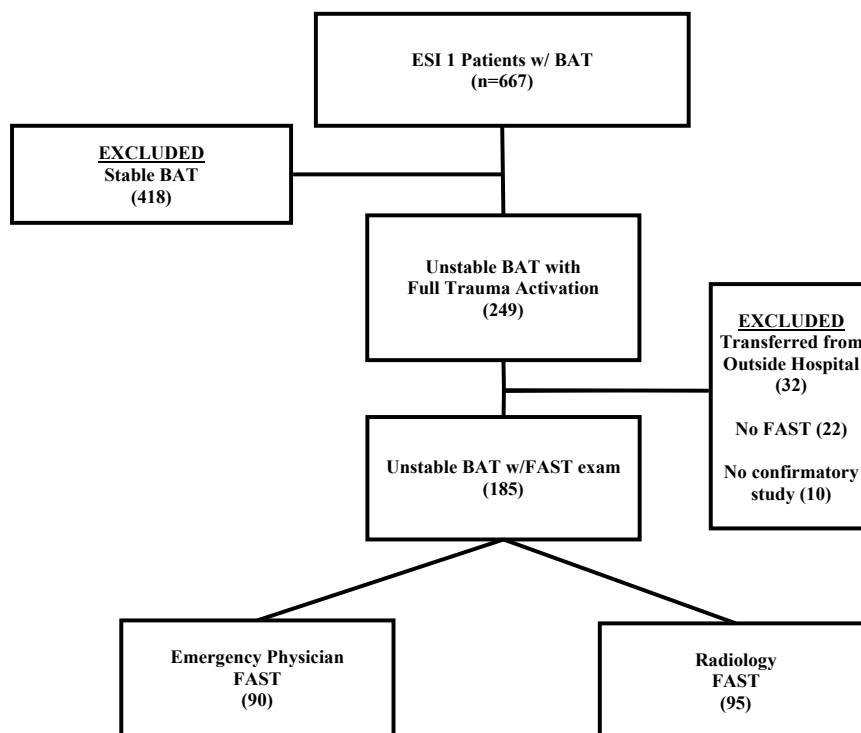


Figure 1: ESI = Emergency Severity Index; BAT = Blunt Abdominal Trauma; FAST = Focused Assessment with Sonography in Trauma.

accuracy were 73% (95% CI 57 to 84%), 98% (95% CI 93 to 99%), and 91% respectively. Inter-rater reliability between two study investigators (AA and BB) was good ($\kappa=0.78$). Test characteristics for hemodynamically unstable BAT patients with moderate to large amounts of hemo-peritoneum, were sensitivity 92%, specificity 98%, and accuracy 97%. The difference in sensitivity between EP FAST exam (76% [95% CI 56 to 89 %]) and radiology FAST exam (69% [95% CI 41 to 87 %]) was statistically insignificant ($p=0.7284$), and both exams had near identical accuracy rates (89% v 93%) making neither exam better or worse than the other.

Diagnostic peritoneal lavage

A total of 71 patients underwent a diagnostic peritoneal lavage to evaluate for hemoperitoneum. Of the 71 DPLs performed, 53 (75%) were performed after a negative FAST, 15 (21%) after an indeterminate FAST, and 3 (4%) after a positive FAST exam. Five patients had grossly positive peritoneal aspirates, four of which had a final operative diagnosis of traumatic hemoperitoneum. 34 DPLs were performed in 79 BAT patients before the new protocol and 38 DPLs were performed in 106 patients after the protocol change. While the overall use of DPL in critically injured BAT patients decreased with the implementation of the new protocol, this trend was not statistically significant ($p=0.17$).

Discussion

One challenge of trauma care is the rapid identification of significant abdominal injuries in hemodynamically unstable patients. Highly accurate, the FAST exam is also repeatable, noninvasive, easily learned and can be performed at the bedside, and thus plays a vital role in the evaluation of trauma patients [12-15].

While computed tomography is the gold standard for diagnosing solid organ injury, the FAST exam is associated with expedited care in BAT, shorter hospital stay, and lower overall cost of care [16-18]. The FAST exam has the potential to mobilize resources quickly for critically injured patients, rapidly identifying those who would benefit from laparotomy

Our findings demonstrate that EP FAST exams in unstable BAT patients had a sensitivity, specificity and overall accuracy of 76%, 98%, and 89% for any amount of free intra-peritoneal hemorrhage. The sensitivity for FAST examinations in our study was somewhat lower than previously reported because our study was designed, a priori, to determine test characteristics for any amount of free hemorrhage, regardless of its clinical significance. It is generally appreciated that the sensitivity of the FAST exam is highest for hemodynamically unstable patients with moderate to large amounts of intra-peritoneal hemorrhage. The FAST exam is limited in its ability to detect trace and small amounts of hemorrhage [18]. With this in mind, EP FAST exams in our study would have demonstrated a sensitivity, specificity and accuracy of 88%, 98%, and 94% respectively for moderate to large amounts of blood in unstable BAT patients, results comparable to published findings in similar patients [19-24]. We did not find a significant difference in test characteristics for FAST performed by the Department of radiology versus EPs.

Limitations

The main limitations to our study were small sample size, single center, and retrospective design. Because we searched for ESI level 1 trauma patients only, patients initially triaged at a lower acuity level,

	CT/OR Positive	CT/OR Negative
FAST Positive	22	1
FAST Negative	7	46
	Sensitivity 76% (95% CI 56 to 89%)	Specificity 98% (95% CI 87 to 99%)
	Accuracy 89%	

Table 2: Emergency Physician FAST.

CT = Computed Tomography and OR = Operating Room

Patient	Mechanism	DPA/DPL	CT	Pelvic Fx	Angiography	OR
13 yo F	Auto v Ped	n/a	smFF	+	n/a	n/a
58 yo F	MVC	-	n/a	+	+	1.5L
22 yo M	MCC	-	n/a	+	-	200cc
69 yo M	BCC	+	n/a	-	n/a	1L
51 yo M	Auto v Ped	n/a	smFF	+	n/a	smFF
24 yo F	Auto v Ped	n/a	trFF	+	n/a	n/a
46 yo M	Train v Ped	+	n/a	+	+	1L

MVC = Motor Vehicle Collision; MCC = Motorcycle Crash; BCC = bicycle crash
trFF = trace free fluid; smFF = small free fluid; yo= years old

Table 3: False Negative EP FAST

	CT/OR Positive	CT/OR Negative
FAST Positive	11	1
FAST Negative	5	63
	Sensitivity 69% (95% CI 41 to 87%)	Specificity 98% (95% CI 90 to 99%)
	Accuracy 93%	

Table 4: Radiology FAST.

CT=ComputedTomography and OR = Operating Room

yet subsequently became unstable, were not identified, and could not be included in this study. Patients with indeterminate FAST exams, no documented FAST exam results, or without confirmatory findings were not included in the analysis, all of which could have significantly changed accuracy rates. Lastly, length of time between the FAST exam and confirmatory testing was not abstracted, thus fluid accumulations that occurred after a negative FAST could not

Patient	Mechanism	DPA/DPL	CT	Pelvic Fx	Angiography	OR
56 yo M	MCC	-	smFF	-	n/a	n/a
23 yo M	Fall	n/a	smFF	+	n/a	n/a
33 yo F	MVC	n/a	smFF	+	+	n/a
18 yo F	BCC	n/a	trFF	-	n/a	n/a
25 yo F	MVC	-	smFF	+	+	n/a

Table 5: False Negative Radiology FAST.

MVC = Motor Vehicle Collision; MCC = Motorcycle Crash; BCC = bicycle crash
trFF = trace free fluid; smFF = small free fluid; yo= years old

be accounted for.

Conclusion

Overall, the FAST exam demonstrated modest sensitivity and high specificity and accuracy for the detection of any amount of intra-peritoneal hemorrhage in hemo-dynamically unstable BAT patients. EP performed FAST showed a sensitivity of 76%, specificity of 98%, and accuracy of 89% for any amount of hemorrhage, test characteristics similar to radiology performed FAST. Utilization of diagnostic peritoneal aspirate and/or lavage in critically injured BAT patients decreased, although the change was not significant.

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