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Focused Assessment with Sonography Exams vs CT Scan

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Abstract

Blunt trauma is a common reason patients present to the emergency department. Providers must evaluate these patients quickly to get them the correct treatment, especially for intra-abdominal bleeding. Focused assessment with sonography for trauma (FAST) exams are growing in use to evaluate trauma patients for free fluid in the abdomen. To be valuable to emergency providers, it must be known how FAST exams compare to the gold standard evaluation, computed tomography (CT) scans. Searches were done on Pubmed and Scopus databases using terms "focused assessment with sonography for trauma" and "FAST exam CT blunt abdominal trauma." Limits were added to only include studies on adults in English, with each FAST being confirmed by CT. The results revealed an average sensitivity and specificity for FAST exams as 54.8% and 92.3% respectively across three quality studies. It can be concluded that positive FAST exams can be used to rule in free fluid in the abdomen, but negative FAST exams must be confirmed by CT scans. Positive FAST exams can reduce the time for a hemodynamically unstable patient to be taken for surgery. In the future, more research must be done to prospectively evaluate FAST exams and to develop training programs for emergency providers.

Introduction

Focused Assessment with Sonography for Trauma (FAST) exams are done using ultrasound machines on a patient's abdomen to assess if there is free fluid in the peritoneal cavity, an indication of hemorrhage after blunt trauma. This non-invasive and inexpensive alternative diagnostic tool is rapidly growing in its popularity in hospitals across the world. FAST exams have been widely used in the US since the 1990s, and they are predominantly used in emergency room settings, with particular importance in rural areas where computed tomography (CT) scans and other more advanced/invasive methods of testing may not be readily available. They are performed by trained individuals, often physicians or ultrasound technicians. A positive FAST exam is depicted by an anechoic space representing free fluid in the upper right quadrant, upper left quadrant, suprapubic, or sub-xiphoid regions.

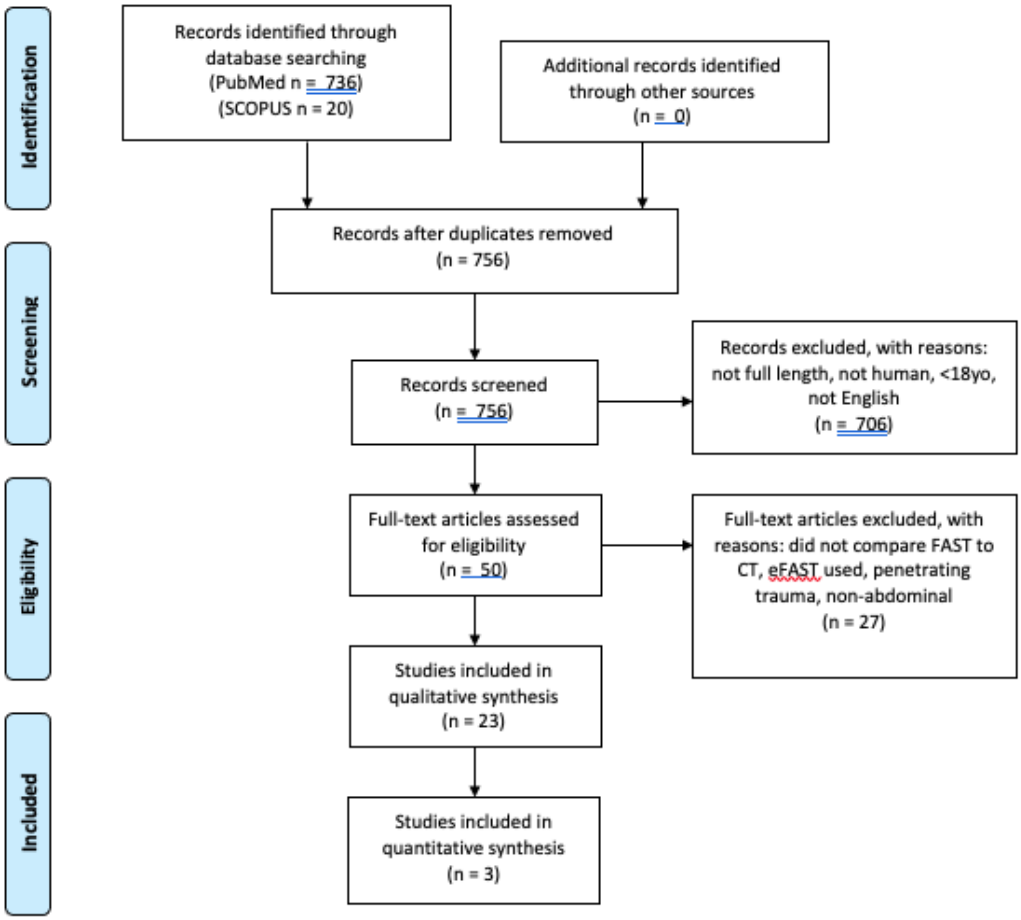
FAST exams have many benefits in the acute trauma setting including being quick, simple, noninvasive, available at bedside, and having no known contraindications. However, FAST exams do have limitations in their sensitivity for free fluid, so CT scans remain the gold standard for assessing abdominal hemorrhages after blunt trauma. Nonetheless, research shows that FAST exams decrease time to surgery and hospital length of stay. Patients with grossly positive FAST exams also undergo fewer CT scans and diagnostic peritoneal lavages, which have more complications and require more time than ultrasounds, because those patients immediately go to surgery and bypass the lengthier diagnostic tests.

This paper will assess three articles comparing the sensitivity and specificity of FAST exams versus CT scans and answer the clinical questions: do adults 18 and older with recent blunt force trauma, is a Focused Assessment with Sonography for Trauma (FAST) exam as effective at detecting free fluid in the abdomen as a CT scan?

Methods

PubMed and Scopus databases were used to search for articles. Search terms "focused assessment with sonography for trauma" and "FAST exam CT blunt abdominal trauma" were

utilized. This yielded 756 results. Articles that did not have free full text, included children under 18 years of age, were not in English, and used animal subjects were excluded from the search. This resulted in 50 eligible articles that were further evaluated based on the inclusion criteria of studies that compared all FAST exams to CT scans, evaluated blunt abdominal trauma patients, and calculated sensitivity and specificity values for FAST exams. Articles were further excluded for using eFAST exams or including penetrating trauma. This resulted in a remainder of 23 articles that were thoroughly analyzed for strictly adhering to the quality assessment criteria, leading to the three final articles: "Accuracy of FAST scan in blunt abdominal trauma in a major London trauma centre" by Fleming S. et al, "Diagnostic accuracy of focused assessment with sonography for trauma for blunt abdominal trauma in the eastern region of Saudi Arabia" by Waheed K.B. et al, and "Not so fast" by Miller M.T. et al. This process is pictured in the PRISMA flow chart.



Results

Study #1

"Accuracy of FAST scan in blunt abdominal trauma in a major London trauma centre" by Fleming S. et al

Objective

To compare FAST exam results to CT scans or laparotomy in blunt abdominal trauma patients coming into a trauma hospital in London.

Study Design

This was a retrospective observational study comparing FAST exams to a definitive diagnostic method. The study took place over one year from January 2007 to January 2008 at the trauma center in the Royal London Hospital. The data was retrieved by accessing completed medical notes. Patients were included who were over 18 years old, presented with blunt abdominal trauma, received FAST exams upon arrival, and also received a CT scan within two hours of admission or underwent a therapeutic laparotomy within 2 days. 84.5% of cases were confirmed by CT, with 15.5% confirmed by laparotomy findings. Patients were excluded if they had incomplete FAST exams or incomplete documentation of CT, clinical, or surgical notes. This resulted in 77 patients meeting criteria with completed medical notes; however 6 were excluded for being hospital transfers, resulting in 71 total patients included in the study.

Emergency room physicians of all levels of practice experience performed the FAST exams depending on availability. A positive FAST scan was defined as the presence free fluid or intra-peritoneal fluid. The contrast CT images were taken from the xiphoid to the pubic symphysis and were immediately read by an on-call radiologist, ranging from first year to senior radiologists. All CT images were reviewed by an attending radiologist at some point. CT scan is traditionally the gold standard for evaluating blunt trauma in the ER, however laparotomy is another way to definitely identify an intra-abdominal bleed.

Results: A true positive was defined as a positive FAST exam and positive pathology on CT or laparotomy. A true negative was defined as a negative FAST exam and negative pathology on CT or laparotomy. A false positive was a positive FAST exam with negative CT or laparotomy, and a false negative was a negative FAST exam with positive CT or laparotomy.

Results

Twenty-five patients had positive FASTs and 46 patients had negative FAST exams. Among them, there were 24 true positives, 18 true negatives, 1 false positive, and 28 false negatives. Of the 42 accurate cases, 31 of these were confirmed with CT and 11 with therapeutic laparotomy. All 29 false positive and false negative results were confirmed with CT scan, but 7 did require therapeutic laparotomy later on. This data reveals a sensitivity of 46.2%, specificity of 94.7%, positive predictive value of 96%, and negative predictive value of 39.1%.

Study #2

"Not So Fast" by Miller M., et al. (2003).

Objective

While FAST exams in the context of acute abdominal blunt trauma have been widely accepted because of their speed and portability, they should be criticized due to their many limitations. The objective of this study is to highlight these limitations, including injuries sustained to the retroperitoneum, hollow-organs, bones, and "incidentalomas" in the context of blunt abdominal trauma.

Study Design

This is a retrospective observational study focused on comparing the reliability and practicality of FAST exams to CT exams, which is the current gold-standard, in detecting the presence of free intraabdominal fluid in patients with blunt abdominal trauma. The population for this study included hemodynamically stable patients who had a high clinical suspicion for blunt abdominal

trauma, which was determined by their triage status and presence of abdominal tenderness on physical exam. Per the protocol outlined in the paper, these patients underwent a routine FAST exam of standard four abdominal views utilizing a 3.5 MHz, Sonosite, Bothell, WA. Within 1 hour of their FAST exam, all patients then underwent an abdominal and pelvic CT scan.
To be sure all persons interpreting the FAST exams were sufficient, all examiners were required to take an accredited course focused in FAST exams; they then individually taught FAST exams to the resident staff in several in-service events and advanced trauma life support training sessions. The CT scans were interpreted by an in-house radiologist. FAST exams were recorded as either "positive" or "negative". A true-positive FAST examination was defined as free fluid detected in one of three abdominal views followed by a positive CT scan. A true negative was defined as free fluid not detected in any of the three abdominal views followed by a negative CT scan. A false-positive was defined as free fluid detected in one of three abdominal views followed by a negative CT scan. A false negative was defined as free fluid not detected in one of three abdominal views followed by a positive CT scan. In all patients confirmed via CT scan to have intraabdominal fluid (true-positive and false-negative FAST exams), the amount of fluid was measured by a separate radiology review of the CT scan. The type of injury was then noted for all patients, including intraabdominal injuries without the presence of free fluid (true negative examinations). These injuries included such findings as retroperitoneum injuries, hollow-organ injuries, bony injuries, and incidentalomas. Incidentalomas are significant diagnoses unknown prior to the injury that were detected on CT and required patient follow-up.

Results

In total, the study evaluated 372 patients over an 8-month period between October 2001 and June 2002. However, 13 patients were excluded from the trial due to their body habitus - it was suspected that this would limit the efficacy of the FAST exam. These 13 patients still underwent a CT scan, for which all 13 were negative for intraabdominal fluid.
Of the 359 patients who underwent a FAST exam followed by an abdominal and pelvic CT scan, there were 313 true-negative FAST exams, 16 true-positive FAST exams, 22 false-negative FAST exams, and 8 false-positive FAST exams. According to calculations, the FAST exam therefore had a 42% sensitivity, 98% specificity, positive predictive value of 67%, negative predictive value of 93%, and accuracy of 92%. The difference between FAST examination and CT scan was statistically significant at 5.85%.

Study #3

Diagnostic accuracy of Focused Assessment with Sonography for Trauma for blunt abdominal trauma in the Eastern Region of Saudi Arabia by Khawaja Waheed et al.

Objective

To determine the diagnostic accuracy of Focused Assessment with Sonography for Trauma (FAST) in blunt abdominal trauma caused by motor vehicle accidents.

Study Design

This was a retrospective observational study of 105 adult patients involved in motor vehicle accidents with blunt abdominal injury presenting to King Fahad Military Medical Complex in Dhahran, Saudi Arabia. The study took place over a period of 1 year, from September 2016 to September 2017. The study was set up to compare the findings of a focused assessment with sonography for trauma (FAST) exam and a computed tomography (CT) scan to determine whether a patient had abdominal free fluid.

FAST exams were performed by senior registrar general surgery team leaders, and the CT scans were read by 2 experienced radiologists with over 7+ years of experience each, who were blinded to the initial FAST scan results. The ultrasound used to perform the FAST exams was an ER portable ultrasound machine using a 3.75-MHz curvilinear probe and the CT scanner was a 128-slice scanner (Siemens SOMATOM definition flash 2010, Munich Germany). Inclusion criteria for the 105 individuals were as follows: adult patients over the age of 14 years, suffered from blunt trauma during a motor vehicle crash and were assessed within 3 hours of crash, had a FAST exam performed within 30 minutes of arrival to ER, and had a CT scan within 2 hours of FAST exam. Exclusion criteria were children (patients less than 14 years of age), pregnant women, and penetrating trauma. FAST exams that were inconclusive or limited were excluded from results. In addition, hemodynamically unstable patients that went immediately to the operating room after a FAST without having a confirming CT scan performed were also excluded. All of the data from the selected patients was collected and analyzed using Statistical Package for Social Sciences, Version 22.

Results

Findings of both the FAST exam and CT scan were either "positive" or "negative" for free fluid, with a true positive being defined as the FAST exam correctly identifying free fluid (CT positive), and a true negative being the FAST exam correctly identifying the absence of free fluid (CT negative). A false positive was if the FAST exam incorrectly identified the presence of free fluid (CT negative), and a false negative was defined as the FAST exam incorrectly identifying an absence of free fluid (CT positive).

Of the 105 adult patients, 87 were men and 18 were women, with a mean age of 32.3 years. Most of the patients were drivers (n=71), unrestrained (n=95), and were in a roll-over motor vehicle crash (n=77). There were 51 true positives, 32 true negatives, 6 false positive, and 16 false negatives. This produced a FAST sensitivity of 76.1% and a specificity of 84.2%, with an accuracy of 79%. Of the 16 false negatives, 8 of those patients were found to have "only minimal free fluid" on CT of less than 50 mL.

Discussion

The results of all three articles represented that FAST exams could be an extremely useful tool in quickly identifying free-fluid in the peritoneal space without the use of costly and radiation-intensive CT scans. However, none of the studies concluded that ultrasound FAST exams are without their limitations.

In the year-long retrospective study conducted by Fleming S. et al, FAST exam results were compared to CT scans and laparotomy surgical procedures on patients with blunt abdominal trauma. Both CT scans and laparotomies are definitive diagnostic modalities for identifying free fluid in the abdomen, which requires urgent intervention. The results of this study found that FAST exams have a high specificity at 94.7%. This means there are few false positives and that a trauma patient who does not have free fluid in the abdomen will most likely have a negative FAST exam. The study also found a high positive predictive value of 96%, indicating that a patient with blunt abdominal trauma who has a positive FAST exam has a high chance of having free fluid in the abdomen. Conversely, this study found that FAST exams have a low sensitivity of 46.2%. This indicates that FAST exams will have many false negatives, and a negative FAST exam cannot be used to rule out free fluid in the abdomen in trauma patients.

Of note, 15% of the patients had their FAST exams confirmed with laparotomy. While laparotomy is both a definitive diagnostic method and treatment for free fluid in the abdomen, it does go beyond the clinical question of this literature review evaluating FAST exams compared to CT scans. Despite this, the design, methodology, and inclusion and exclusion criteria are reliable and valuable to assess the efficacy of FAST exams. The authors also identify no conflicts of interest and no funding for this study.

A strength of this study is that it utilizes data over one full year in a trauma hospital in a large city. This method allows a long window of time to evaluate FAST efficacy. It also utilizes records from actual medical practice, which provides data that is relevant to how FAST exams are clinically being used. Another strength of the methodology in this study is that each CT scan was confirmed by a consult level, attending radiologist to reduce CT reading errors. This study also followed-up every FAST exam with a definitive diagnostic method, whereas other research often utilizes physical exam and patient status to confirm FAST results. By only using confirmed FAST exams, there is more confidence in the data used to calculate sensitivity and specificity.

There are also several limitations in this study. As the records were collected retrospectively, the data relied on medical notes from providers that are subject to recall bias and there was no randomization or blinding. The providers also had no standardized training on performing the FAST exams; there was no formal or documented training for using the ultrasound, and the scans were performed from emergency room physicians ranging from first year residents to attendings. However, the authors found there was no difference in false negative rates between residents and attending physicians. Another potential weakness of the study is that the time between FAST exam and CT scan varied and was allowed up to 90 minutes between. It is possible that free fluid was absent during a FAST exam but accumulated by the time CT was performed, increasing the number of false negative FASTs.

During the 8-month retrospective study performed by Miller et. al., FAST exams were performed on 359 patients presenting to a level 1 trauma center with blunt abdominal trauma. Within the hour, these patients also underwent an abdominal CT, which is the gold standard for detecting free fluid in the abdomen. This study determined that FAST exams had a sensitivity of 42% and a specificity of 98%. This means that if free fluid was detected on FAST exam, there was a 98% chance that there was, in fact, free fluid in the abdomen, as confirmed on CT. However, if free fluid was not detected in the abdomen, there was only a 42% chance that this was a true-negative finding, as confirmed on CT. In other words, while FAST exams were reliable for identifying true-positive findings of free fluid in the abdomen, there was also high likelihood of having a false-negative, where the FAST exam missed free fluid in the abdomen. This is why, in practice, if a FAST exam is positive patients may go straight to surgery; however, if a FAST exam is negative, this finding is always confirmed with an abdominal CT.

There are no conflicts of interest with any of the authors. Strengths of this study include assuring that all persons performing and interpreting the FAST exams underwent the same training. All ultrasound exams, including FAST exams, are often difficult to regulate because these exams are user-dependent: their reliability is determined by the person performing the exam. Additionally, all FAST exams were quickly compared to abdominal CT, which is currently the gold standard for detecting free fluid in the abdomen. By directly comparing the findings of the FAST exam to that of the abdominal CT, the precise specificity and sensitivity of FAST exams compared to abdominal CTs can be calculated. Other strengths of this study include how the authors stratified their final results. For every person, the authors included several subcategories of patients, including their triage status, mechanism of injury, clinical and laboratory findings, and the final

diagnosis of the patient, regardless of whether the patients were FAST positive or negative. By including this information, it helps clinicians to see exactly how reliable FAST exams are at detecting free fluid in patients fitting a certain set of criteria.

Weaknesses for this study include that all patients were required to be hemodynamically stable. This may be why their numbers were relatively low: blunt abdominal trauma is a common occurrence, so less than 400 participants over the course of 8 months with otherwise very lax inclusion data was quite a small sample size. By including hemodynamically unstable patients, their data may look very different, as it would be likely that many of these patients would have hemorrhage to some degree, thus theoretically producing a true-positive FAST exam. Another reason this may be the case is because there was potentially up to an hour between FAST and abdominal CT; most of these injuries are progressive, and thus free fluid may not have been detectable during the time of the FAST exam and were measurable an hour later when the abdominal CT was obtained. Additionally, the exclusion criteria included persons with a significant BMI. The reason for this was that the adipose tissue would obscure the results, which is a known downfall to FAST exams in common practice. However, information that was not provided were the BMIs of these patients, as well as if their data was incorporated into the final results, as all 13 persons excluded still underwent CT exams.

In the study done by Waheed et al. in Saudi Arabia with 105 patients, we see that many of the themes remain the same in which the FAST exam is a useful tool for quick analysis of free fluid in the abdomen in the event of blunt trauma. The study was a year long, a decent amount of time given to collect information that incorporates every season and thus a more well-rounded demographic. The study was done at a tertiary care military hospital, and thus immediate care for all emergency trauma patients was available. CT scans were available at this hospital all 24 hours of the day, so there was never a time information wouldn't have been collected due to lack of accessibility of a CT machine. All patients that were included in the study results presented to the ER within three hours of their trauma, a strength of the study because of its uniformity. A major strength of the study as well was that the FAST exams were all done by senior registrars (i.e. attending physicians) who were very experienced in FAST exams, so user incompetency was not a factor in this study, possibly leading to its highest sensitivity of the three articles discussed. Additionally, the CT scans were all read by two experienced radiologists, and even more notably, the CT radiologists were blinded from the original FAST exam results, preventing bias.

The Waheed study had many strengths, but also some critical weaknesses that would warrant further investigation. First, the CT scans were not always done immediately after the FAST exams, with some CT scans not happening until two hours after the FAST exam. This is a weakness of the study because a patient could have had a very small bleed that led to a negative FAST exam but two hours later had much more fluid in the abdomen that CT would easily pick up on. The study does mention that 8 of the 12 false negatives were shown on CT to have "minimal fluid" (less than 50 mL) and admits that this is a limitation of ultrasound in its sensitivity to pick up small fluid amounts. The study also only included patients that were in motor vehicle accidents, which limited its study group. If it had included all blunt trauma, it would have had larger study group and may have generated more impressive predictive values. Surprisingly, the study also only included patients that received a FAST exam and a CT exam. Patients that had a positive FAST exam and went straight to surgery (bypassing CT) were excluded from the study, which is a confusing piece of information since surgery would be the

gold standard of confirming there was a bleed, so why wasn't these patients' results included as true positives?

As depicted in Table 1, all three studies showed that FAST exams are notably more specific than they are sensitive, with Miller M. et al finding the highest specificity at 98%, and Waheed et al the lowest at 84.2% though this study had the highest sensitivity for FAST exams. Overall, the data among these three studies indicate that positive FAST exams have a high specificity, meaning that a trauma patient with free fluid in the abdomen will likely have a positive FAST exam, and that there are few false positives. They also demonstrate that FAST exams have a low sensitivity, meaning that there are many false negatives and that a negative FAST exam must be followed up by a definitive diagnostic method.

Table 1. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) across three studies.

	Sensitivity	Specificity	PPV	NPV
Fleming S., et al	46.2%	94.7%	96%	39.1%
Miller M., et al	42%	98%	67%	93%
Waheed, et al	76.1%	84.2%	89.5%	66.7%

Conclusion

Based on the data provided in the articles included in this literature review, it can be concluded that FAST examinations have a low sensitivity (average 54.77%) and a high specificity (92.3%). This means that while a positive FAST exam is reliable and does indicate free fluid in the abdomen or peritoneum, a negative FAST exam does not rule out the presence of free fluid in trauma patients. Negative FAST exams should be confirmed by an abdominal CT. In practice today, this is often seen. FAST exams are financially beneficial and quick to perform at the bedside. Often while patients are awaiting CT, a clinician will perform a FAST exam on a patient with blunt abdominal trauma, and it may change the course of care - in the emergency setting, minutes matter. In those hemodynamically unstable with a positive FAST exam, an abdominal CT is generally foregone and instead the patient is rushed to laparotomy to stop the bleeding. In patients hemodynamically stable with a positive FAST, they will still undergo an abdominal CT to quantify the amount of fluid and help surgeons for more thorough surgical planning. For those with a negative FAST exam, all patients will undergo an abdominal CT to confirm the findings on the FAST exam, regardless of being hemodynamically stable or unstable.

While this is common practice in most developed countries, hospitals in many parts of the world (rural areas of developed countries, developing countries, etc.) do not have a CT machine. In hospitals such as these, FAST exams would be extremely beneficial because they are both cost-effective and are statistically more sensitive and specific than clinical findings alone for trauma. In the absence of CT, FAST exams are a reliable source to improve patient morbidity and mortality.

In the future, the literature would benefit from prospective FAST exam studies to better evaluate their efficacy; current research at this time only utilizes retrospective studies. Resources should also be devoted to developing training for providers and students on both how to perform FAST exams and how to interpret their results.

Citations

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