

Focused Abdominal Sonography for Trauma (FAST)

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Abstract

This study aims to examine the feasibility of applying the focused ultrasound examination (FAST) in the initial assessment of the trauma patient. Its advantage over diagnostic peritoneal lavage lies in the speed in which it can be performed, its non-invasiveness and repeatability.

Over the period January 1997 to July 1998, the FAST examination (Acuson 128XP/10, 3.5 MHz probe) was used to assess the presence of haemopericardium or haemoperitoneum in 38 multi-trauma patients admitted to the Singapore General Hospital. The sample comprises mainly males (82%) with a mean age of 34 years (range 17 to 77 years). The mechanism of injury was predominantly blunt (95%). Mean Injury Severity Score (ISS) was 22. Eleven patients presented in shock and 16 patients had abdominal tenderness on examination. A single surgeon did the examination, which was performed during the secondary survey phase of resuscitation. Time taken for the FAST examination averaged 2.3 ± 1.3 minutes. The results of the examination were compared to diagnostic peritoneal lavage, CT scan, operative findings, serial examination and/or post-mortem findings. Overall sensitivity was 67% and specificity 97%. Although the FAST examination missed the small amount of free fluid seen in the CT scan of 2 patients, these patients did not have to undergo laparotomy as their abdominal examination was normal. We conclude that the FAST examination is feasible and should be part of a general surgeon's armamentarium in the initial assessment of trauma.

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Introduction

The multiply injured patient presents a challenge to even the most experienced surgeon. These patients often present in shock and require a rapid diagnostic work-up to determine the presence of ongoing haemorrhage. Clinical examination alone is known to be unreliable in this group of patients.^{1,4} The introduction of diagnostic peritoneal lavage by Root in 1965 subsequently revolutionised the management of these patients.⁵ Its high sensitivity has, however, led to a high rate of non-therapeutic laparotomies.⁶ In addition, it is an invasive test which carries a complication rate of approximately 1% (bowel and vascular injury). The increasing use of computed tomographic (CT) scan in the 1980s has increased the accuracy of diagnosis of the trauma patient. However, its use is limited to patients who are stable enough to be transported to the CT room. As early as 1970, Goldberg had shown ultrasound to be a sensitive method for detecting intra-peritoneal fluid.⁷ A year later, Kristensen et al⁸ from Germany published the first case report of ultrasound use in a trauma patient. Asher et al⁹ subsequently reported a sensitivity of 80% in the detection of splenic injury and established ultrasound find-

ings in splenic injury. In 1988, Chambers and Pilbrow¹⁰ suggested that ultrasound be used as an alternative to diagnostic peritoneal lavage for trauma patients.

In Japan and Germany, ultrasonography has been used by clinicians in the trauma room for the past 20 years.^{11,12} However, the use of ultrasound for trauma in North America is a relatively new phenomenon. The first report of patients evaluated by ultrasonography was by Paul Tso at the Shock Trauma Centre in Baltimore in 1992.¹³ The examination was done by surgical trauma fellows with only 1 hour theoretical training and 1 hour of practical training. It was only 69% sensitive for detecting intra-abdominal injury. The sensitivity was much higher (91%) if only the detection of haemoperitoneum was considered. Clinicians soon realised that if the ultrasound examination was simplified and focused on looking only for free fluid, even a non-radiologist could perform the examination rapidly and with a high degree of sensitivity and specificity. This was especially important, as it is often the emergency physicians and trauma surgeons who see the patients in the middle of the night. This limited examination to look for free fluid has been called the focused abdominal sonography for trauma

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(FAST).^{14,15} The portability, non-invasiveness and repeatability of FAST effectively makes it an extension of the clinical examination. In Germany, proficiency in ultrasound is mandatory in the general surgery residency programme and has been called the surgeon's stethoscope.¹ Reports have shown that a non-radiologist could perform FAST examination to screen for free fluid in trauma patients with comparable accuracy as their radiology colleagues.^{1,2,4,11,16-22}

At the Singapore General Hospital, diagnostic peritoneal lavage and CT scans have been used as adjuncts to clinical examination in assessing multiply injured patients. The purpose of this article is to provide a review of FAST and to report on a prospective study to validate the use of the focused abdominal sonography for trauma (FAST) by local surgeons to rapidly evaluate the multiply injured patient.

Materials and Methods

The Singapore General Hospital is a 1600-bedded tertiary hospital in Singapore. It receives trauma patients according to a zoning system. At the Accident and Emergency Department, multiply injured patients are triaged to the resuscitation room by the Emergency Room physician. The trauma team is then activated. The patients are managed according to the established Advanced Trauma Life Support® protocol. Patients with abdominal trauma with clear indications for laparotomy (for example, peritonitis) are brought directly to the operation theatre. For patients with suspected abdominal injury, further evaluation either by diagnostic peritoneal lavage or CT scan will be required. In general, patients who present in shock (systolic blood pressure <90 mmHg) and who remain haemodynamically unstable after initial fluid resuscitation are subjected to diagnostic peritoneal lavage. Patients who are haemodynamically stable are sent for CT scan.

The study population comprises trauma patients seen by the author between January 1997 and July 1998, and this represents a non-consecutive patient population. The first author had previous exposure to the FAST examination during his trauma fellowship in Canada. The FAST examination was performed using the Acuson 128XP/10 machine (3.5 MHz sector transducer probe) during the secondary survey phase of resuscitation with the patient in the supine position. The results, including the time taken for completion of examination, were documented before the performance of diagnostic peritoneal lavage or CT scan and were not used in management decisions. The examination was focused and designed to look for free fluid in 4 dependent areas—pericardium, Morissons pouch, spleno-renal recess and pouch of Douglas.¹ The probe positions are as shown in Figure 1. The examination was recorded as positive if free fluid was found in any site and negative if none was

found. There was no allowance for indeterminate or equivocal response, so that the levels of sensitivity and specificity for the examination may be determined. Examples of positive FAST examinations are shown in Figures 2 to 4. Diagnostic peritoneal lavage was carried out using the percutaneous Seldinger technique (Cook peritoneal lavage set, C-PLS-901) and considered positive if there were aspiration of bile, enteric contents or >10 ml of gross blood. CT scan was performed and reported by radiologists who were unaware of the results of the FAST examination. The presence of free fluid, organ injury or retroperitoneal haematoma were recorded. CT scan was considered positive only if free fluid was present. The FAST results were compared with results obtained from diagnostic peritoneal lavage, CT scan, operative findings, serial observations and/or post-mortem findings. Validation was positive if any of these confirmed the ultrasound findings of free fluid. All patients were followed up till discharge or death. Clinical data were collected prospectively and entered into a database and analysed (SPSS Version 7). Injury Severity Scores (ISS), Revised Trauma Scores (RTS) and probability of survival (Ps) as determined by the Trauma and Injury Severity Score (TRISS) methodology were calculated using a commercial trauma registry software (COLLECTOR, Tri-Analytics, Inc).²³⁻²⁶

Results

Of the 38 patients accrued over the 19-month study period, 31 were males and 7 were females. The mean age was 34 ± 15 years (range 17 to 77 years). The mechanism of injury was predominantly blunt (95%). Falls from height contributed to 42% of cases and road traffic accidents another 45%. Eleven patients (29%) presented

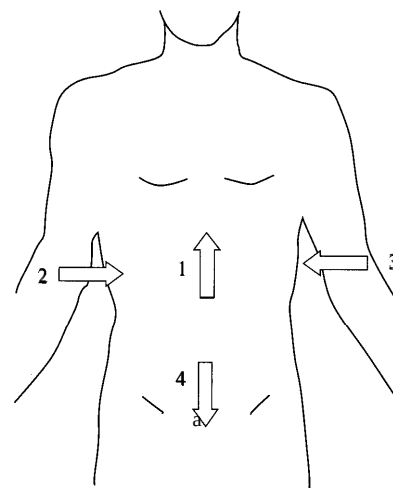


Fig. 1. Schematic diagram showing the 4 transducer positions used in the focused abdominal sonogram for trauma (FAST) examination. 1: Subxiphoid view for haemopericardium; 2: Right upper quadrant view for blood in Morissons pouch; 3: Left upper quadrant view for blood in perisplenic region; 4: Suprapubic view for blood in pouch of Douglas.

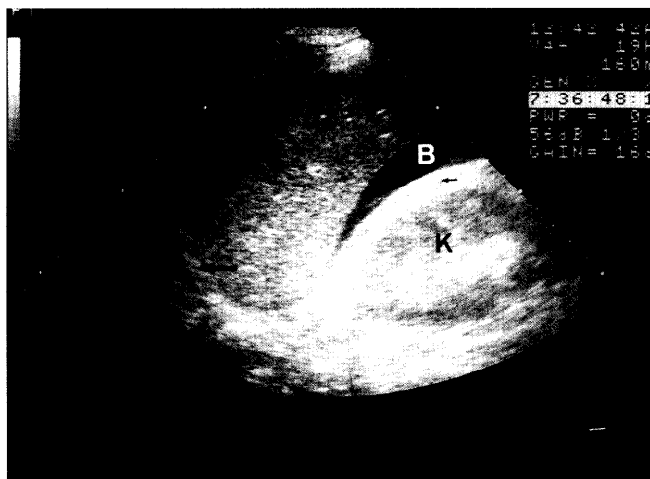


Fig. 2. Positive FAST showing blood in Morrison's pouch as a hypoechoic crescent between liver and right kidney. B: blood; L: liver; Large arrow: diaphragm; Small arrow: perinephric fat.

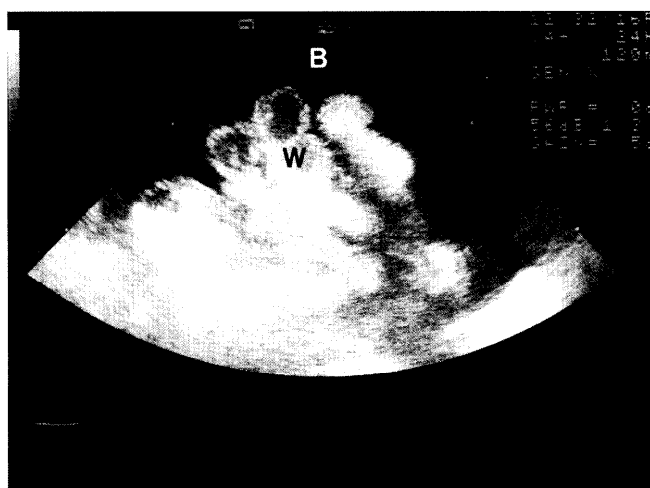


Fig. 4. Massive haemoperitoneum evident as the hypoechoic area within which are multiple floating bowel loops. B: blood; W: bowel loops.

with hypotension. Ten patients (26%) had severe head injury (Glasgow Coma Scale <8). Sixteen patients (42%) had abdominal tenderness on examination. The mean Injury Severity Score (ISS) was 22 ± 11 . Seventy-one per cent of patients have major trauma as defined by ISS >16. Of the 4 patients who died, representing an overall mortality of 10.5%, 3 had probability of survival, Ps <0.5 (0.1235, 0.3118 and 0.3880). The fourth patient had a Ps of 0.6509 and an ISS of 25, and died of diffuse intracerebral bleeding.

Twenty-six CT abdomen scans and 2 diagnostic peritoneal lavage were performed. Ten patients were observed clinically with no missed injury. Two patients underwent laparotomy, both of which were therapeutic. The first patient was found to have a liver laceration from a stab wound (FAST positive) and the second had traumatic stomach transection from a roll-over accident (FAST positive). The other two patients with true positive FAST examination had liver and splenic injury with

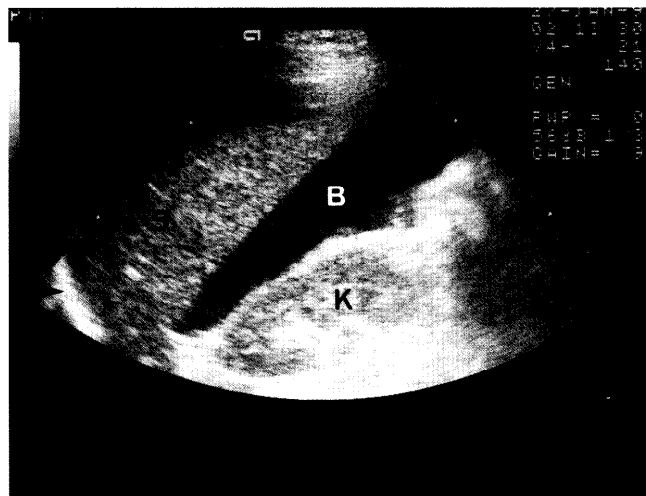


Fig. 3. Blood in the perisplenic region shown as a hypoechoic area around the spleen. The left kidney lies below the spleen and the hyperechoic line seen in the left lower corner represents the left diaphragm. B: blood; S: spleen; K: kidney; Arrow: diaphragm.

haemoperitoneum shown on CT scan. Both were treated conservatively.

The mean time for performance of the FAST examination was 2.3 ± 1.3 minutes. Five examinations (13%) were positive for free intraperitoneal fluid. No patient had haemopericardium on FAST examination. The results are summarised in Table I. There were 1 false positive and 2 false negative ultrasound examinations. The only patient with a false positive examination was involved in a road traffic accident, sustained left rib fractures and extremity fractures. His ultrasound showed left haemothorax and what appeared to be a rim of fluid around the spleen. Abdominal CT carried out before operative fixation showed no intraperitoneal fluid or solid organ injury. Both patients with false negative FAST examination did not require any intervention. The first patient, involved in a jet ski accident, was admitted with left upper quadrant pain and normal blood pressure. Her ultrasound was negative for free fluid but CT scan performed 2½ hours later revealed a small perisplenic haematoma which was treated conservatively. The second patient was a motorcyclist involved in a road traffic accident, admitted in shock and had a Glasgow Coma Scale of 7. He sustained severe head injury, burst frac-

TABLE I: COMPARISON OF EAST WITH A VALIDATION TEST* (CT SCAN, DIAGNOSTIC PERITONEAL LAVAGE, OBSERVATION, LAPAROTOMY, AUTOPSY FINDINGS) IN THE ASSESSMENT OF A MULTIPLY-INJURED PATIENT

	Validation test	
	Positive	Negative
Ultrasound Positive	4	1
Negative	2	31

Sensitivity 67%; Specificity 97%; Accuracy 92%; Positive predictive value 80%; Negative predictive value 94%.

ture of the 5th cervical vertebrae with quadriplegia and multiple limb fractures. CT scan subsequently showed some fluid in the left paracolic gutter just below the spleen that was managed conservatively.

Analysis of the results indicates that this focused examination of trauma patients by ultrasound has a sensitivity of 67%, specificity of 97%, accuracy of 92%, positive predictive value of 80% and negative predictive value of 94%.

Discussion

There was initial apprehension among radiologists on the use of the ultrasound by clinicians in the trauma room. Several papers on large series of patients screened by the FAST examination have since shown that radiologists, surgeons and emergency room physicians were equally capable of performing the FAST examination.^{1,2,4,11,16-22} In one study, Rozycki and Shackford¹⁴ compared a collected series of 4941 patients where surgeons performed the FAST examination with a series of 997 patients where radiologists performed the examination and found similar levels of sensitivity (93.4% versus 90.8%), specificity (98.7% versus 99.2%) and accuracy (97.5% versus 97.8%). Buzzas et al²² conducted a study involving both surgeons and radiologists, and found no difference in capability of performing the FAST examination between the two cohorts. Ultrasound is no longer domain specific as obstetricians, cardiologists and even general practitioners have been using it for years. It is logical that surgeons and emergency room physicians should perform the FAST examination on trauma patients, as they are often the ones to receive the patients in the emergency room. The focused approach is easy to learn despite controversy among clinicians as to the amount of training required. Recent courses on FAST have included 8 hours of didactic lectures and hands-on practice sessions.^{27,28} A period of proctoring by experienced examiners is essential.¹⁴ When this is not available, validation by a gold standard is necessary. Boulanger et al¹⁸ found that the time taken for a clinician to carry out the trauma ultrasound plateau at just over 2 minutes after approximately 50 to 75 examinations.

Some reported false positive FAST examinations have been due to misinterpretation of what is perceived as a small sliver of fluid as was the case with the one false positive in this study.^{20,21} These should more appropriately be labelled as equivocal and followed by a repeat FAST or CT scan.²⁹ It is conceivable that cirrhotic patients with ascites may give rise to false positive examinations because it is not possible to distinguish between ascitic fluid and blood. This underscores the importance of distinguishing these patients clinically by looking for stigmata of liver disease.

Two patients in this study with false negative FAST examinations were shown to have small amounts of

blood near the spleen. Neither required surgery. If we had only considered the ability of the FAST examination to predict a therapeutic laparotomy, its sensitivity would be 100% for this study. It is possible that the FAST examination may miss detecting small amounts of free fluid that are present in some injuries, especially bowel injury.^{11,18,30,31} As bowel injury is more common in penetrating abdominal trauma than in blunt, FAST will conceivably be less useful in the former group? In a conscious cooperative patient, serial clinical examination will diagnose the majority of bowel injuries. When a reliable clinical examination is not possible, suspect cases may be confirmed by diagnostic peritoneal lavage.

Can the FAST examination replace the traditional gold standard of diagnostic peritoneal lavage and CT scan in the assessment of abdominal trauma? At least in Europe and Japan, ultrasound has largely replaced diagnostic peritoneal lavage as a screening tool.^{11,12} This has also been the trend in some trauma centres in North America.^{4,18} The overall sensitivity for FAST is not as high as diagnostic peritoneal lavage. This may be an advantage as the high sensitivity of diagnostic peritoneal lavage has led to many non-therapeutic laparotomies. Although repeating the examination later when more blood has accumulated can increase its sensitivity, clinicians should always perform repeated clinical examination and exercise good clinical judgement.^{1,11} The FAST examination was devised to only look for free fluid and is unable to specify which organ is injured. Ultrasonography for the detection of solid organ injury is a more difficult skill to acquire. The CT scan remains the test of choice for demonstrating and staging solid organ injury. Branney and Boulanger^{4,18} have independently proposed fairly similar algorithms (Fig. 5) to screen trauma patients on the basis of the FAST examination and haemodynamic stability. The use of FAST in the preliminary screening for injury may reduce the use of the more expensive CT scan or invasive diagnostic peritoneal lavage. The efficiency of FAST was demonstrated in the 1988 Armenian earthquake, where 400 mass casu-

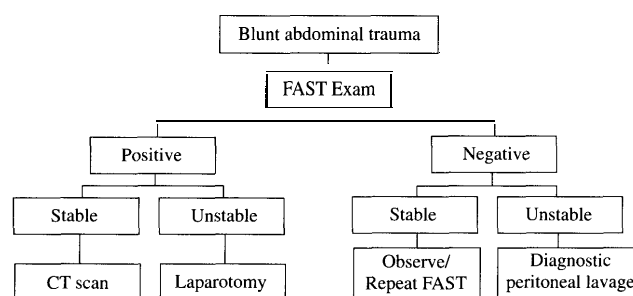


Fig. 5. Algorithm utilising the FAST examination to screen patients with multiple trauma. Unstable patients with negative FAST are subjected to diagnostic peritoneal lavage because of its higher sensitivity. Stable patients with negative FAST who cannot be observed because of severe head injury or logistic reasons should have a CT scan.

alties were screened within 72 hours of arrival at a large hospital.³² Notwithstanding, there are certain circumstances when the FAST examination may be difficult or impossible to perform. These include obesity, subcutaneous emphysema, excessive bowel gas and the presence of wounds or tenderness over the area of placement of probe. In such instances, an equivocal or indeterminate response is appropriate and the patient either observed or other tests performed.²⁹

The use of the FAST examination in the trauma setting is a novel application in Singapore. The biggest advantage is the rapidity in which it is able to demonstrate blood in the pericardium, pleural cavity and peritoneum in an unstable multiply injured patient. Having this knowledge will allow the trauma surgeon to rapidly prioritise the management of the patient's different injuries. For example, transfer of a hypotensive patient to the operation theatre can be expedited if the FAST examination shows a large haemo-peritoneum or haemopericardium. On the other hand, the absence of significant haemoperitoneum in a patient with an unstable pelvic fracture will suggest the need for an angiogram instead of laparotomy. The FAST examination can also be used as a screening tool in stable patients, thereby reducing the utilisation of expensive tests like the CT scan for screening purposes. We conclude that the FAST examination is feasible and should be part of a general surgeon's armamentarium in the initial assessment of trauma.

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