A Cross-Sectional Study Comparing the Diagnostic Accuracy of Focused Assessment with Sonography in Trauma (FAST) and Multidetector Computed Tomography (CT) Scan in Patients with Abdominal Trauma

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Abstract:

Background and Objectives: Traumatic abdominal injuries rank as the leading cause of death for those under 45years, mostly due to hypovolemic shock. Detecting hemoperitoneum and hemopericardium is the aim of the Focused Assessment with Sonography in Trauma(FAST). We compared the multidetector Computed Tomography(MDCT) scan with FAST to evaluate the diagnostic accuracy of FAST as a first tool in patients with abdominal injuries.

Patients and Methods: A descriptive study was conducted in the Emergency Medicine Departments of Assiut and Alexandria Main University Hospitals to investigate abdominal trauma among100individuals.Each patient had a FAST examination and an (MDCT) scan of their abdomen. The main aim was to evaluate the sensitivity and specificity of FAST in detecting the presence or absence of intra-peritoneal free fluid collection as an indirect sign of acute bleeding and damage to intra-abdominal or pelvic organs, in addition to evaluating the patients' outcomes, either therapeutic laparotomy or observation with follow-up, and then discharge.

Results: FAST had identified hemoperitoneum with 98% accuracy; however, it could not identify any pancreatic injury or retroperitoneal hematoma.FAST overall accuracy was96.3%,95.9%,and81.2%in identifying hepatic, splenic, and renal injuries, respectively.

Conclusion: FAST is preferred for initial assessment of traumatized individuals since it offers a reasonable sensitivity for identifying hemoperitoneum in addition to advanced hepatic and splenic damage. More investigations are needed to reach a definitive judgment.

Keywords: Accurate diagnosis; Targeted evaluation using sonography in trauma; Abdominal trauma.

Introduction:

Surgeries are frequently performed on the abdomen, which is the third most frequently injured section in over a quarter of trauma patients. Abdominal trauma can be categorized into penetrating injuries, which are easily identifiable, and blunt trauma, sometimes missed due to less obvious clinical indications(1-2). Recent research has identified risk factors for mortality in abdominal trauma. These include sex, time from injury to surgery, shock upon admission, and head injury. Former studies have added that old age and lung contusion were also predictors for mortality (3-4). Focused Assessment with Sonography in Trauma(FAST) is commonly utilized as an initial imaging test (2). FAST is a readily available, affordable, reliable, and non-

invasive method that may be conducted at the patient's bedside with minimal preparation time. It can also be done using portable tools, allowing patient placement flexibility (5-6). Hemoperitoneum lesions, including those affecting the colon, diaphragm, and mesentery, require a thorough evaluation using the multidetector Computed Tomography(MDCT)after FAST.MDCT is the best imaging method for detecting intraperitoneal free air or fluid, assessing organ damage severity, and identifying retroperitoneal injuries.However,it is laborious,expensive,and carries a significant risk of repeated radiation exposure. It is often used after FAST to determine the feasibility of non-surgical treatment for unstable hemodynamics(7-9).Our objective was to evaluate the diagnostic precision of FAST in comparison to the gold standard MDCT scan of the abdomen as a first assessment tool for patients with abdominal injuries.

Patients and Methods

Study Design and Setting

This study was conducted at Assiut and Alexandria Main University Hospitals, specifically in Egypt's Emergency Medicine Department. It took place from July 2021 to June 2022 and was approved by the Medical Ethics Committee at Assiut University(reference number 17101725 on 9/5/2022). The study was also registered on ClinicalTrials.gov before enrolling patients(NCT04896463,18 May 2021). Patients who chose not to participate received the standard optimal medical care. The study included patients aged 18 years or older who experienced abdominal trauma, either an isolated injury or part of a polytrauma, and whether a piercing or a blunt mechanism caused it. Excluded from the study were pregnant women, patients who underwent urgent surgical exploration as part of the initial assessment, patients who were clinically unstable and unable to undergo an MDCT scan, patients who required multiple transfers, and patients who refused to participate.

Sample Size Calculation

The study design was cross-sectional, and a minimum sample size of 100 patients was enrolled to achieve the study objective. This sample size was determined based on the theory of Monte Carlo simulations, which suggested that using a 100 $(1 - \gamma)$ percent upper one-sided confidence limit on δ will provide a sample size necessary to achieve the intended power in at least 100 $(1 - \gamma)$ percent of such studies. It is assumed that the value of γ is zero.

Methodology

Study Tools

A comprehensive clinical evaluation was conducted on all patients, including a thorough history, clinical evaluation, and laboratory data. The primary survey included initial assessments of airway, breathing, circulation, and neurological evaluations, identifying life-threatening conditions. The patient's condition was classified as stable or unstable using the revised trauma score (RTS), a widely used physiological assessment system.

Radiological Evaluation

MDCT

The scan was carried out using 16 (GE Medical System) or 64 (Aquillion) MDCT scanners.

Patients were positioned properly on the CT table to achieve high-quality CT studies. The patient was laid supine, with the arms either placed over the head to prevent beam-hardening artifacts, or if that was not applicable, the patient's arms were placed ventrally to the chest and flexed on a large pillow.

IV contrast administration was injected, adapted to the body weight,120ml to 150ml of non-ionic iodinated contrast media (270mg iodine/ml), injected at a rate of 3ml/s, which was adequate.

The arterial phase scan was initiated 20-30 seconds after the start of injection. In the Porto venous phase, the scan was delayed till 80 seconds after injection. The late scan was useful for renal trauma in evaluating renal

excretion and function. The scan was done at a delay of 100 sec post-injection for the nephrogenic phase and 6- 10 min post-injection to evaluate the collecting system and the urinary bladder.

FAST

- **A MEDISON (X6 SONOACE)** ultrasound machine with a curvilinear probe was utilized.
- **Four standard views** were obtained:
  1. **Subxiphoid transverse view:** The probe was placed below and to the right of the xiphoid process, angled toward the patient's left shoulder to visualize the pericardial space.
  2. **Right upper quadrant longitudinal view:** This included the right kidney, Morison's pouch, and the right lobe of the liver.
  3. **Left upper quadrant longitudinal view:** This included the left kidney, spleen, and the space between them. The probe was placed at the level of the eighth rib along the posterior axillary line.
  4. **Pelvic view (rectouterine pouch and urinary bladder):** The probe was moved inferiorly or superiorly as needed to inspect the entire bladder region.
- The probe was moved in multiple directions in both upper quadrant views to thoroughly examine the region.

Primary Objective:

To evaluate the sensitivity and specificity of the FAST exam in detecting intraperitoneal free fluid collections, which may indicate acute hemorrhage and visceral organ injury in the pelvis or abdomen.

Secondary Objective:

To determine the patients' clinical outcomes, including those who underwent therapeutic laparotomy or were observed and subsequently discharged.

Statistical Analysis

The statistical package for the social sciences, or SPSS, version 20, created by IBM with its main office located in Armonk, New York, was used to evaluate the collected data. Whereas continuous data was shown as the mean ± standard deviation or median (range), nominal data was shown as a percentage. A receiver operator characteristic (ROC) curve was used to evaluate the FAST scan accuracy. Because the confidence level was fixed at 95%, a P value less than 0.05 was deemed significant.

Results

Baseline data and mechanism of the studied patients (Table 1):

The patients' average age was 33.36 ± 12years. Of the patients registered, 85% were men. The most frequent modes of trauma were motor car accidents (42%), falls from height (18%), and motorbike accidents(16%).

Findings in MDCT and FAST among the studied patients (Table 2, Figures1-2):

Based on MDCT assessment, it was found that 100 (100%),79(79%),51 (51%), 29(29%), 5(5%), and 3 (3%) patients had intraperitoneal free collection, hepatic injuries, splenic injuries, renal injuries, pancreatic injuries, and retroperitoneal hematoma, respectively. Meanwhile, with FAST scan, it was found that 98 (98%),76 (76%),49 (49%), and 10 (10%)patients had intraperitoneal free collection, hepatic injuries, splenic injuries, and renal injuries, respectively. So, the FAST scan did not detect pancreatic injuries or retroperitoneal hematoma.

Management and final outcome of the studied patients (Table 3):

Fifty-two percent of patients required only observation, while surgical intervention was done in 48(48%)patients. Ninety-five percent of patients were improved and discharged, and only 5 (5%) patients deteriorated and died.

Accuracy of FAST in detection of different abdominal injuries (Table 4, Figure 3-5):

FAST scan has98% accuracy for detecting IPF, while failing to detect any cases with pancreatic injury or retroperitoneal hematoma. For the detection of hepatic injuries, while the area under the curve (AUC) of the FAST scan is 0.981, it has an overall accuracy of 96.3% for splenic injury identification. The FAST scan,

meanwhile, has an overall accuracy of 81.2% and an AUC of 0.672 for the diagnosis of renal damage.

Legend of Tables

Table 1: Baseline data and mechanism of trauma of the studied patients

	N= 100
Age (years)	33.36 ± 12
Sex	
Male	85 (85%)
Female	15 (15%)
Mechanism of trauma	
Motor car accident	42 (42%)
Fall from height	18 (18%)
Motorbike accidents	16 (16%)
Firearm injuries	15 (15%)
Stab wound	9 (9%)
Associated injuries	
Upper limb fracture	37 (37%)
Fracture spine	22 (22%)
Hemothorax	13 (13%)
Lower limb fracture	10 (10%)
Pelvic fracture	7 (7%)
None	11 (11%)
Stability of patients	
Stable	76 (76%)
Unstable	24 (24%)

Data expressed as frequency (percentage), mean(SD), and range.

Table 2: Findings in computed tomography and FAST among the studied patients

	CT findings	FAST findings
Intraperitoneal free collection	100(100%)	98(98%)
Hepatic injuries	79(79%)	76(76%)
Splenic injuries	51(51%)	49(49%)
Renal injuries	29(29%)	10(10%)
Pancreatic injuries	5(5%)	0
Retroperitoneal hematoma	3(3%)	0

Data expressed as frequency(percentage).

Table3: Management and final outcome of the studied patients

	N=100
Management	
Conservation	52(52%)
Surgical intervention	48(48%)
Outcome	
Alive	95(95%)
Died	5(5%)

Data expressed as frequency(percentage).

Table 4: Accuracy of FAST in the detection of different abdominal injuries

	Hepatic injury	**Splenic injury**	**Renal injury**
Sensitivity	96.2%	94%	35%
Specificity	100%	98%	100%
PPV	100%	98%	100%
NPV	87.5%	94%	78.9%
AC	96.3%	95.9%	81.2%
AUC	0.981	0.960	0.672
P value	< 0.001	< 0.001	0.009

PPV: positive predictive value; NPV: negative predictive value; AC: accuracy; AUC: area under the curve. *P*-value was significant if < 0.05

Legend of Figures

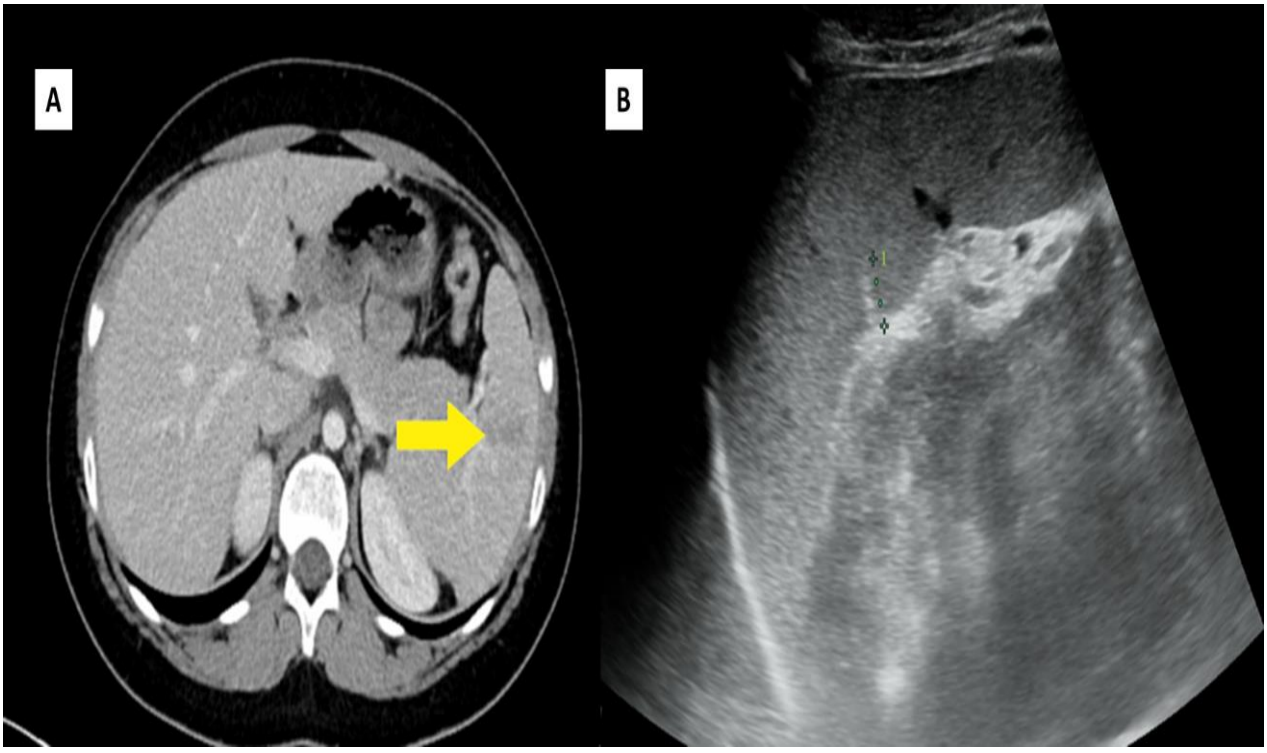

Figure1: Case number1.A19-year-old male presented complaining of mild left-sided abdominal pain after falling from a motorbike on the left side of his body. A**:** Axial view of contrast-enhanced CT of abdomen, suggesting grade 2splenic lacerations showing multiple linear hypo-density extending from the splenic hilum reaching up to 2.5 cm; **B**: FAST scanning may be performed and revealed disruption to the splenic echotexture indicating laceration.

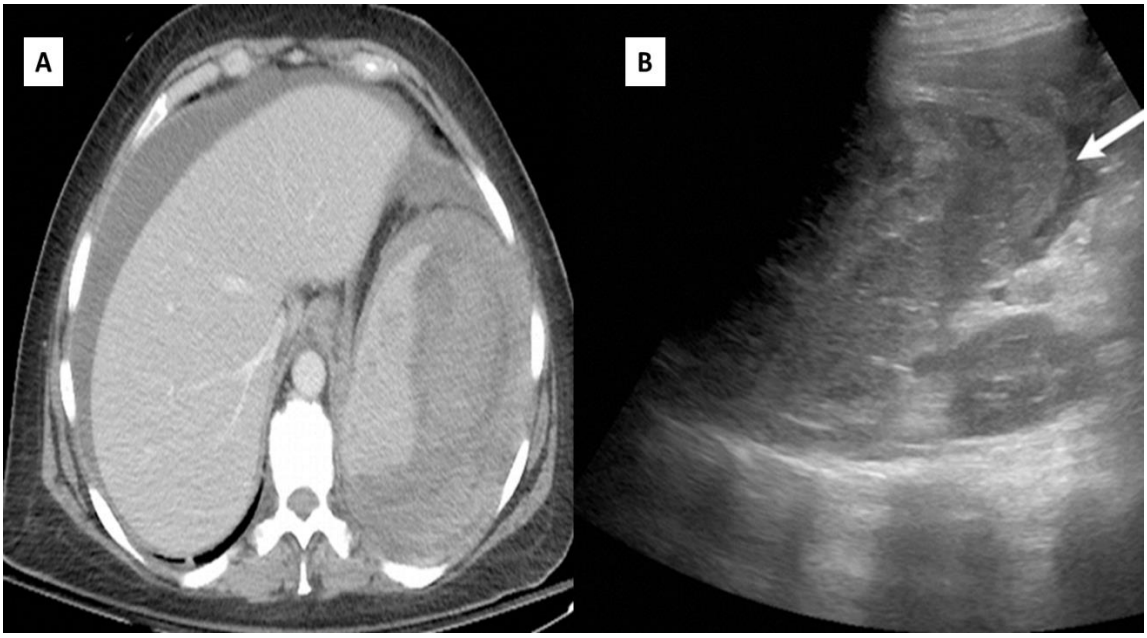

Figure 2: Case number 3. A 44-year-old man with blunt abdominal trauma from a motor vehicle accident had abdominal pain. **A**: Initial CT scan showed marked heterogeneity of the spleen with free fluid. **B**: bedside FAST examination demonstrated free fluid in the upper abdomen

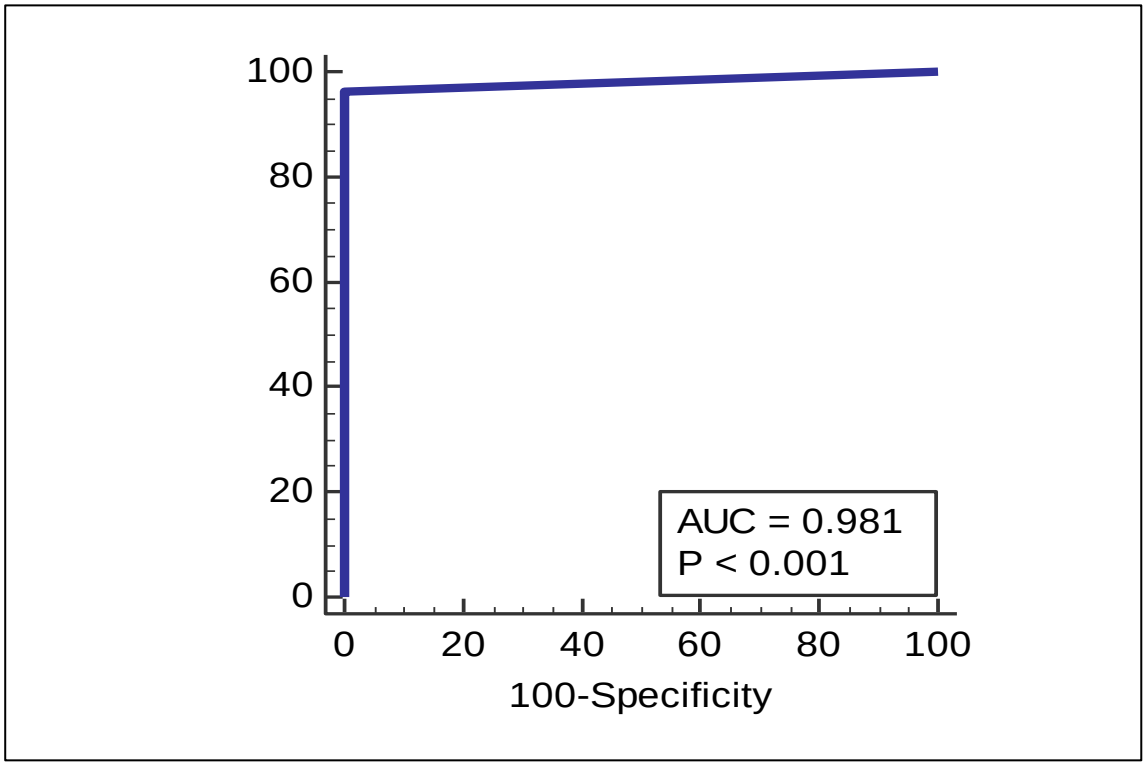

Figure 3: Accuracy of FAST in the detection of hepatic injuries

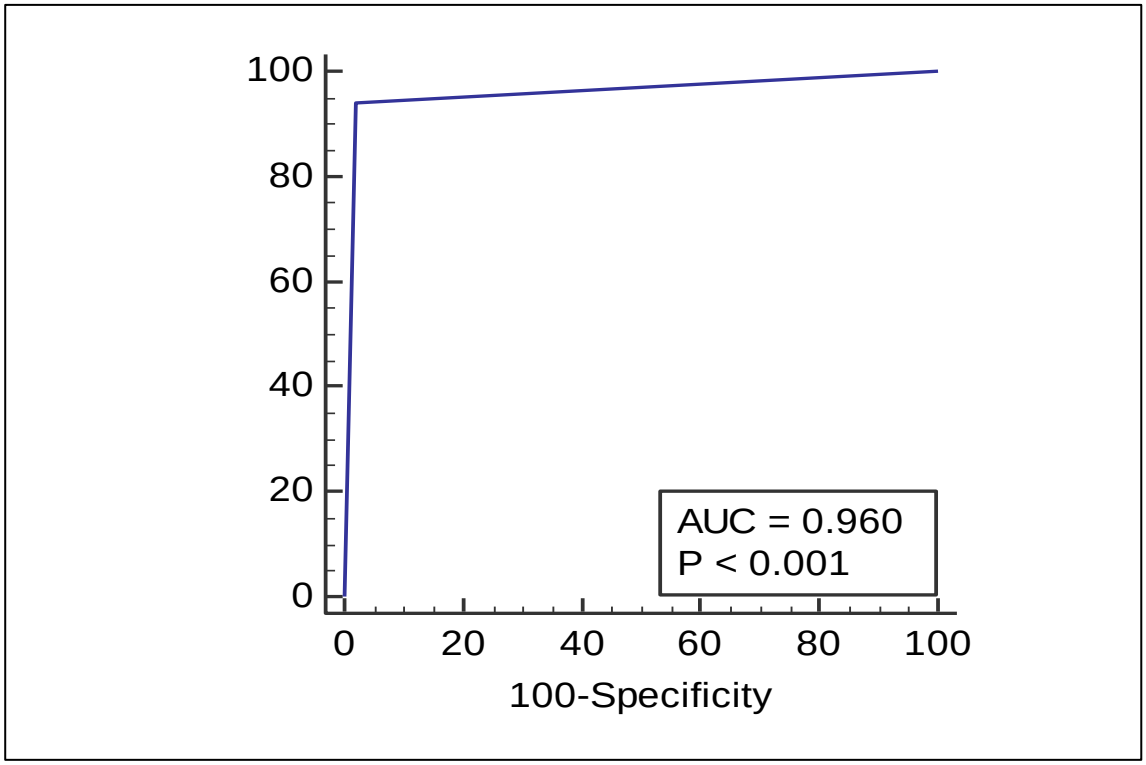

Figure 4: Accuracy of FAST in the detection of splenic injuries

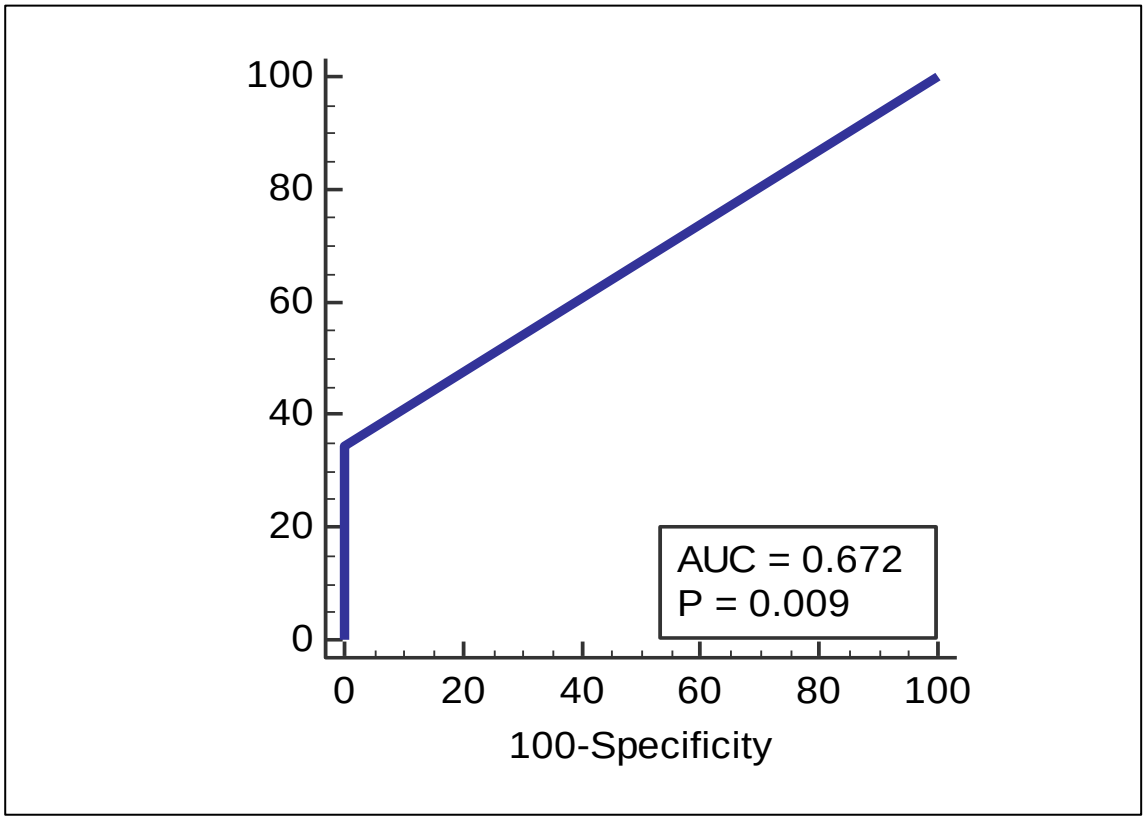

Figure 5: Accuracy of FAST in the detection of renal injuries

Discussion

Prompt detection of concealed intra-abdominal injuries using ultrasound, MD CT, laboratory tests, and physical examination was crucial for reducing morbidity and mortality(11). Our trial included100patients, with an average age of 33.36 ± 12years. Males were predominantly affected at 85%, compared to15%of females. This finding was concerning as it affects economically productive groups aged between15and85years(3-4). We found that motor car accidents(42%), falls from height (18%), and motorbike accidents(16%)were the most common trauma modes, with 76% of patients being hemodynamically stable. Additionally, we reported in our study that almost76% of the patients suffered blunt abdominal injuries; that is consistent with other reported findings(12-14). However, few reported that penetrating injuries are the most frequent mechanism of abdominal trauma(15). Our study found that11%of patients had abdominal injuries without other associated injuries, while the most commonly injured organs in polytrauma patients were upper limb fractures(37%), spine fractures(22%), and hemothorax (13%). Lower limb fractures were present in 10% of patients, and 7 % had pelvic fractures. This made sense as the majority of patients had experienced falls from heights and traffic accidents. Concomitant extra-abdominal injuries and severe injuries were linked in this study to increased rates of morbidity and mortality.

Our study found that 100 (100%), 79 (79%), 51(51%), 29(29%), 5(5%), and 3(3%) patients had intraperitoneal free collection, hepatic injuries, splenic injuries, renal injuries, pancreatic injuries, and retroperitoneal hematoma, respectively. Meanwhile, with FAST scan, it was found that 98 (98%),76 (76%),49 (49%), and 10 (10%)patients had intraperitoneal free collection, hepatic, splenic, and renal injuries, respectively. So, the FAST scan did not detect pancreatic injuries or retroperitoneal hematoma. Fifty-two percent of our patients required only observation, while surgical intervention was done in 48(48%)patients. The majority (95%)of patients who underwent observation improved and were discharged, and only 5(5%) patients deteriorated and died. Another study found that all patients through MDCT had IPF collection, while FAST detected it in 83.9%of patients. The most frequently damaged organs were the liver(73.2%)and spleen(51.8%), followed by the kidneys and pancreas in 46.4% and12.5% of patients, respectively(16). This study produced almost similar results because they had comparable research populations and designs.

Our study found that the FAST scan has98% accuracy for detecting IPF, but failed to detect pancreatic injury or retroperitoneal hematoma. It had 95.9% accuracy for splenic injury identification and 96.3% for hepatic injuries. The scan had an overall accuracy of 81.2% for renal damage diagnosis.FAST was designed to identify individuals who might benefit from early surgical intervention by detecting hemoperitoneum in adult trauma.FAST in research done on adult abdominal trauma showed accuracy ranged from 97% to 99%, positive predictive values from73% to83.3%, negative predictive values from 84% to 98.9%, sensitivity from 80% to 88%, and specificity from98.3%to100%.(17-18).In trauma, FAST showed respectable sensitivity (76.1%), specificity (84.2%), and accuracy (79%)in detecting intraperitoneal free fluid(19).

Nevertheless, Tabassum et al reported having 167 patients over six months with respective values of 84%,92% and88% for sensitivity, specificity, and accuracy in detecting haemoperitoneum (20). Adams et al. also found that FAST had82%sensitivity and99% specificity, respectively, in cases involving intra-abdominal injuries among adults(21). The sensitivity of FAST in hypotensive patients ranges from79% to100%, with a specificity of 68% and a sensitivity of 90% in a subgroup of 1277 patients with hypotension, 40% of whom were associated with free fluid(22). **Schnuriger et al.**found that grade III solid

organ lesions were more often recognized than grade I and II lesions because FAST sensitivity and specificity are significantly connected with injury severity (23). **Szmigielski et al.** stated that the FAST is an unreliable imaging modality for diagnosing renal parenchymal injuries(24). This is in accordance with our results, as the sensitivity of FAST in the detection of renal trauma was the lowest in comparison to the liver and the spleen, which showed a significant difference, even though there was a patient with a completely devascularized kidney, and the FAST was unremarkable. Thus, we concluded that FAST cannot be used as a sole imaging study in case of suspected renal injury and can easily miss significant renal injuries where MDCT should be the imaging of choice, as well as in pancreatic and retroperitoneal injuries, where MDCT also showed a superior accuracy.

The study had limitations, including a small sample size, the time difference between the initial assessment and later imaging that caused a bias toward more false negatives, and the inability to distinguish blood from urine, bile, or ascites. However, FAST is a valuable tool for assessing and triaging trauma patients, particularly in detecting hemoperitoneum and advanced splenic and hepatic injuries, besides identifying patients who need to have a laparotomy. Negative findings should be correlated with further clinical examinations, as some patients may require an MDCT examination despite a negative FAST to be well managed. Future research should explore the potential benefits of combining clinical data and sonography in trauma assessment for better patient outcomes. It should use serial FAST examinations to increase its sensitivity and use abdominal MDCT scans.

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