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Comparison between ultrasound imaging modalities and computed tomography scan findings with their application for surgical management of blunt thoracoabdominal trauma victims: A Prospective observational study

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Abstract:
Blunt thoracoabdominal trauma is a major emergency condition requiring rapid and accurate diagnosis for effective surgical management. Although computed tomography scan is considered the gold standard, ultrasound imaging modalities are commonly used in emergency settings because they are rapid and easily available. Therefore, it is of interest to compare the ultrasound imaging modalities with computed tomography scan findings and evaluate their application in the surgical management of blunt thoracoabdominal trauma victims. Data shows the evaluated a combined imaging approach using E-FAST, repeated E-FAST, delayed ultrasonography and CT in trauma patients at a tertiary care center. Initial E-FAST showed high sensitivity, while repeated and delayed ultrasound improved specificity and reduced dependence on CT in selected cases. Thus, structured ultrasound-based pathway can support timely triage and surgical decision-making, especially where CT access is limited.

Keywords: Focused assessment with sonography for trauma (FAST), abdominal injuries, lung injury, developing countries, X-ray computed tomography (CT)

Background:
Trauma is a leading cause of death globally, claiming more than five million lives and nearly one billion people require medical care for injuries annually. Low and middle-income countries (LMIC) are confronted with a devastating reality in which approximately 2 million injury-related deaths would be avoidable by implementing basic, protocolized trauma management care in LMIC **[1].** In many resource-limited settings, timely diagnosis is hindered by limited access to advanced imaging, dependence on operator expertise and logistical barriers to patient transfer. In contrast to high-income countries (HIC), where Computed Tomography (CT) scanning is readily available, healthcare systems in LMIC often rely on alternative diagnostic pathways that balance speed and resource constraints by optimizing rapid, bedside diagnostic modalities such as Focused Assessment with Sonography for Trauma (E-FAST) and delayed routine ultrasonography (late USG). Blunt injuries are frequently a result of road traffic accidents, assaults or falls and solid organ injuries like the Spleen and liver are the most commonly affected organs **[2].** Establishing a relationship between the severity of external and internal injuries can help physicians to identify internal injuries early, distinguish between severe and non-severe internal injuries and initiate prompt treatment **[3].** Currently, the management of blunt thoracoabdominal trauma (BAT) has undergone a paradigm shift to a more conservative approach owing to the development of new therapeutic modalities and advances in critical care management, which have increased the chances of non-surgical management. Traditionally, CT has been established as the preferred diagnostic method for assessing blunt trauma in hemodynamically stable patients. CT abdomen not only detects intra-abdominal injury, but also other associated injuries such as hemothorax, lung injuries, fractures of the lower ribs, fractures of the spine and pelvis. The increasing exposure to ionising radiation associated with CT imaging may pose significant health risks **[4].** Factors like the high cost of scans, difficulties in transporting patients and the shortage of available CT scanners tend to pose more immediate and practical obstacles to obtaining imaging in these environments. E-FAST offers several advantages, including real-time imaging, repeatability and reduced radiation exposure **[5].** Despite these strengths, the system also has limitations its sensitivity is lower for certain injuries, E-FAST accuracy depends heavily on the operator's skill and small or subtle injuries can be difficult to detect. Due to these factors, a single E-FAST scan may not provide a comprehensive diagnostic picture. Performing subsequent and repeated E-FAST (rE-FAST) scans, however, can be highly valuable. It allows clinicians to monitor changes in injuries over time, track recovery or deterioration and make more informed treatment decisions. By developing cost-effective ultrasound techniques that complement CT imaging, healthcare providers can enhance diagnostic accuracy and improve outcomes in trauma care. Repeated and integrated ultrasound assessments may help overcome the limitations of E-FAST, supporting more

effective surgical and clinical decision-making. Therefore, it is of interest to substantiate E-FAST as a primary diagnostic tool in combination with late USG, possibly strengthening initial trauma assessment protocols to prioritise speed and diagnosis and decrease reliance on CT scans, thereby improving patient outcomes in LMICs.

Methods:

Study design and setting:

This prospective study was conducted for 1.5 years at an apex tertiary care center in central India. This study specifically targeted individuals who sustained blunt trauma to the thoracic and abdominal regions, with a focus on epidemiological patterns, diagnostic efficacy and subsequent clinical management strategies. The methodologies employed included advanced ultrasound imaging modalities, CT imaging technologies and surgical intervention techniques.

Ethics statement:

The ethical approval was granted by the Ethics Committee on 17.01.2023, approval no. AIIMS/BPL/IHEC-LOP/2022/IL073. Written informed consent for participation in research, along with recording of clinical details in an available proforma and for publication of research details and clinical images, was obtained from all patients.

Participants:

Upon presentation, all participants underwent an E-FAST scan as an initial diagnostic measure to quickly assess free fluid and organ injury at initial and repeated timepoints (3- and 6-hours post-admission), termed rE-FAST. This was followed by ultrasonography 24 hours later, whenever required for further diagnosis and surgical management, termed late USG. Initial E-FAST examination at presentation, using linear probes across five key interfaces (hepatorenal, splenorenal, pericardial, pleural and pelvic), with repeated E-FAST examinations **(Figure 1)**. The free fluid detected was classified as mild free fluid when depth of <2 cm seen in one recess (Morison's pouch or pelvis), moderate free fluid when depth of 2–5 cm, seen in ≥2 sites (hepatorenal + splenorenal or pelvis) and gross free fluid when depth was >5 cm, extending across recesses with bowel floating or recess distention **[6].** Definitive CT imaging using a 256-slice CT helical scanner was performed when necessary to identify extra-thoracoabdominal and missed internal injuries, with solid organ injuries and classified according to the American Association for the Surgery of Trauma injury score grading criteria. Trained radiology residents performed all ultrasound examinations to minimize bias.

Data collection:

Data collection involved detailed recordings of patients, including their epidemiology, initial and repeated E-FAST examinations, late ultrasound scans and subsequent CT findings, as well as intraoperative findings, wherever applicable. Complications and subsequent follow-up were noted in the study protocol and Master's Excel chart. Based on previous studies, 5 % disease prevalence (p) (average of thoracic injuries 4.6% and abdominal injuries 4.3%) and a precision (d) of 5%, while assuming a 95% confidence level (z), we calculated the sample size using the following formula:

$$n = \frac{z^2 . p . (1 - p)}{d^2}$$

Statistical analysis:

The sample size was 72.9; therefore, 75 trauma patients were included in the study. Statistical analyses were performed using SPSS (version 27.0; SPSS Inc.). Measures of central tendency and dispersion (mean and standard deviation), inferential statistics (chi-squared test, t-tests, Fisher's exact test) and correlation statistics (McNemar's test, Fleiss' Kappa) were used to assess the diagnostic performance of E-FAST, late USG and CT and their relationship with the final operative findings. A P-value of less than 0.05 was considered to indicate statistical significance at a 95% confidence level.

Results:

The study comprised 75 hemodynamically stable blunt trauma patients with a mean age of 33.29 years, with a predominantly male population (n = 63, 84%) with a smaller proportion of female patients (n = 12, 16%) and a majority of trauma patients (n=62, 82.7%) sustained injuries attributable to road traffic accidents (RTAs) **(Table 1)**. In this study, we used the term E-FAST to refer to the combination of initial and rE-FAST findings to calculate the common diagnostic efficiency. The E-FAST performed in seventy five patients demonstrated a distribution in which 54.67% (n = 41) of the patients showed mild free fluid with nine patients underwent surgery, 18.67% (n = 14) had moderate free fluid, four patients underwent surgery, 4% (n = 3) exhibited gross free fluid with two patients underwent surgery and 22.67% (n = 17) were negative for free fluid with five patients underwent surgery. E-FAST demonstrated moderate sensitivity (ranging from 66.7% to 82.4%, depending on the location) and high specificity (generally > 78%), indicating its reliability in ruling out significant injuries. A chi-square (χ^2) correlation analysis suggested that management decisions were significantly associated with E-FAST free fluid level findings (χ^2 = 24.76, degrees of freedom (df) = 6, P < 0.001) **(Table 2)**. Based on the E-FAST findings, the analysis compared the management decisions (conservative vs. surgical). Among the 75 patients, 17 had negative E-FAST findings; of these, 70.6% (12/17) received conservative management and 29.4% (5/17) required surgery after further investigation. Fifty-eight patients had positive E-FAST findings: 69.0% (40/58) were managed conservatively, 25.9% (15/58) underwent surgery and 5.2% (3/58) died or left against medical advice. The odds of conservative management were slightly higher in positive E-FAST cases (OR = 1.28, 95% confidence interval (CI): 0.89–1.84); however, this association was not statistically significant (p = 0.072) **(Table 3)**. Fluid location analysis revealed that the pleural cavity had the highest number of cases (28 cases, 48.2%), while the pelvic cavity presented with a lower incidence of cases (13 cases, 22.4%). The peritoneal cavity (17 patients, 29.3 %). Cochran's Q test results ($Q = 236.53$, $df = 3$, $p < 0.0001$) indicated a statistically significant difference in diagnostic performance across different anatomical locations, implying that the effectiveness of E-FAST varied depending on the site of application. Late USG was performed in 34 patients, prompting surgical intervention in 28.58% of cases (8/28). Of these, five patients showed gross hemoperitoneum on late USG and the other two underwent intercostal drainage tube insertions. Meanwhile, 71.42 % (20/28) continued with conservative care, demonstrating the role of USG in guiding delayed decision-making. There was a statistically significantly lower risk of remaining in surgical treatment after late USG compared to conservative treatment (RR = 0.40, 95% CI: 0.213-0.752, P-value- 0.0013), while patients initially assigned to conservative management showed no significant change in treatment direction (RR = 1.00, 95% CI: 0.437-2.289, P-value-1.000). It also influenced injury detection, as late USG identified evolving mainly thoracic injuries (*e.g.,* seven hemothorax and two pneumothorax cases) that were missed on initial E-FAST, although with lower sensitivity than CT (*e.g.,* late USG detected 15 hemoperitoneum cases vs. CT 42). CT was performed in 43 patients, with 27 patients managed conservatively and 16 managed surgically. McNemar's test was used to evaluate the effect of late ultrasonography (USG) on treatment decisions. The test revealed a statistically significant difference in treatment direction ($\chi^2 = 4.32$, $df = 1$, $N = 28$, $P = 0.036$) compared with the critical value from the chi-square distribution with one degree of freedom ($\chi^2 = 3.84$, $P = 0.05$). Since $4.3 > 3.84$, the result was statistically significant at a significance level of 0.05, suggesting that late USG had an influence on a shift toward conservative management **(Table 4)**. For solid organ injuries, for pancreatic injuries, CT had high detection rate but high agreement ($\kappa = 0.85$), while other solid organs showed sufficient detection rate and high agreement values for liver ($\kappa = 0.78$), spleen ($\kappa = 0.71$) and kidney ($\kappa = 0.82$) among diagnostic modalities needed for detection but E-FAST systematically missed subtle injuries including subcapsular hematomas and retroperitoneal pathologies; late ultrasound identified delayed injuries but performed poorly for retroperitoneal organs like the pancreas. In hollow viscus injuries, CT detected all six bowel injuries and 4 bladder cases, maintaining more sensitivity for bladder (4/4) and bowel (6/6) detection with more kappa agreement ($\kappa = 0.66$), whereas E-FAST and late USG demonstrated lower agreement ($\kappa = 0.64$), progressively lower detection rates and served better as adjunctive tools. Pneumoperitoneum was detected in 12 cases by CT (1 conservative, 11 surgical) and late USG, detecting 7 cases by late USG and demonstrated moderate agreement ($\kappa = 0.62$, $P = 0.003$). For hemoperitoneum, CT detected 42 cases (26 conservative, 16 surgical), E-FAST identified 36 cases and late USG detected 15 cases, with moderate agreement ($\kappa = 0.69$, $P < 0.001$). For chest injuries, E-FAST demonstrated surprisingly high sensitivity (83.33%) and specificity (95.67%) for pneumothorax and hemothorax (sensitivity 93.75%, specificity 96.33%), making it valuable in point-of-care settings despite missing approximately 14–15% of cases with agreement values of ($\kappa = 0.73$-0.76, $P < 0.001$) among diagnostic modalities; however, CT remained indispensable for detecting occult pneumothorax, hemothorax and rib fractures (three cases with 100% sensitivity), where E-FAST showed notably lower sensitivity (66.67%) for the latter **(Table 5)**. Surgical interventions performed in 28 of the 75 cases included exploratory laparotomy (16 cases) and the management of injuries, such as bowel perforation or hemorrhage. Splenectomy (five cases) was performed for severe splenic injuries (grade IV/V), while distal pancreatectomy (three cases) addressed pancreatic transections or lacerations. Primary repair (9 cases) sutured perforations in hollow organs (*e.g.,* 6 jejunum, 2 duodenum, 1 colon) and resection and anastomosis (5 cases) removed gangrenous or damaged bowel segments. Loop ileostomy (3 cases) diverted fecal flow post-resection, while omental patch repair (2 cases) reinforced duodenal defects. Damage control surgery (three cases) prioritized hemorrhage control in unstable patients. Post-operative revisions, such as stomal leak repair (2 cases), addressed complications. One case underwent negative laparotomy, diagnosed as having mild fluid on E-FAST and later USG showed a suprapubic collection. Afterwards, CT was done, showing pneumoperitoneum, with a negative laparotomy prevalence of 6.25% (1 out of 16) in the surgically managed group. Minimally invasive techniques, such as ultrasound-guided pigtail insertion (5 cases), draining intra-abdominal collections and intercostal drain placement (12 cases), were used to manage pneumothorax or hemothorax. Debridement and wound repair (3 cases) addressed contaminated injuries and percutaneous nephrostomy (1 case) relieved the urinary obstruction. Endoscopic Retrograde Cholangiopancreatography guided pancreatic duct stenting (1 case) ensured ductal patency. Minimally invasive techniques, such as ultrasound-guided pigtail insertion (5 cases), intercostal drain placement (12 cases), debridement and wound repair (3 cases) and percutaneous nephrostomy (1 case), were performed. In our study, we differentiated follow-up patients into those with uncomplicated follow-up, characterized by regular hospital admissions and recovery periods without significant clinical or radiological complications. For conservatively managed patients, this included those with stable or resolving injuries requiring only observation. For surgical patients, it implied a smooth post-operative course without major complications such as infections or reoperations. Complicated follow-up course patients who experienced adverse events during the follow-up period. The study's trauma victims follow-up data showed that 42 patients who managed conservatively came for follow-up (33 patients had an uncomplicated course, 9 lost to follow-up) and the 28 patients who underwent surgical treatment during their hospital course all returned for follow-up (18 patients had an uncomplicated course, 9 had a complicated course and one lost to follow-up) **(Table 6)**. Values are presented as numbers (%). E-FAST, Extended Focused Assessment with Sonography for Trauma; LAMA, Leave against medical advice; df = degrees of freedom; [a)] Fisher's exact test was used due to the small sample size; [b)] Test for overall effect $\chi^2 = 24.76$,; P value< 0.001, df =6; [*] P<0.001 (Statistically significant) Values are presented as numbers (%). E-FAST, extended focused assessment with

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sonography for trauma; LAMA, left against medical advice; OR, Odds ratio; M-H, Mantel-Haenszel Test; CI, Confidence interval; Ref, Reference value. a) Odds ratio for conservative vs. Surgical management, b) Test for overall effect χ^2 = 3.24, P-value = 0.072 calculated M-H using the test; P<0.05(Statistically significant) Values are presented as numbers (%). Numbers in parentheses represent (Conservative/Surgical) cases; E-FAST, Extended Focused Assessment with Sonography for Trauma; CT, computed tomography; Late USG, Late Ultrasonography; a) Kappa (κ) statistics comparing CT with E-FAST and Late USG findings.; * P <0.05 (Statistically significant) Values are presented as numbers (%).; Late USG, Late Ultrasonography; RR, Relative risk ratio; CI, Confidence interval; a) Cochran's McNemar's test for management change: χ^2 = 4.32, P = 0.036*; * P <0.05 (Statistically significant).

Table 1: Demographic analysis of blunt trauma victims

Parameter	Category	n (%)	p-value
Age (years)	Mean (SD)	33.29 (13.39)	0.152
Age distribution	18–25	28 (37.3%)	
	26–35	15 (20.0%)	
	36–45	18 (24.0%)	
	46–55	11 (14.7%)	
	56–65	3 (4.0%)	
Sex	Male	63 (84.0%)	0.10
	Female	12 (16.0%)	
Mechanism of Injury	Road traffic accident	62 (82.7%)	0.08
	Fall from height	11 (14.7%)	
	Assault	2 (2.7%)	

Values are presented as numbers (%); SD= standard deviation; P<0.001(Statistically significant)

Table 2: Chi-square correlation between E-FAST findings based on the amount of free fluid and management decisions

Fluid Status	Total Cases (n=75)	Conservative (n=52)	Surgical (n=20)	Death/LAMA (n=03)	χ^2 value	P-value
Negative	17 (22.7%)	12 (23.07%)	5 (25%)	-	6.24	0.044
Mild	41 (54.7%)	30 (57.8%)	9 (45%)	2 (66.7%)	12.83	0.002
Moderate	14 (18.7%)	10 (19.2%)	4 (20%)	-	4.57	0.102
Gross	3 (04%)	0	2 (10%)	1 (33.3%)	8.33 a)	0.016
Test for overall effect b)					24.76	< 0.001*

Table 3: Mantel-Haenszel Test for correlation between E-FAST findings and Management Decisions

Initial Finding	Total Cases (n=75)	Conservative Management (n=52)	Surgical Management (n=20)	Death/LAMA (n=03)	OR M-H test (95% CI) a)
E-FAST Negative	17 (22.7%)	12 (23.07%)	5 (25%)	0	1.0 (Ref)
E-FAST Positive	58 (77.3%)	40 (76.9%)	15 (75%)	3 (100%)	1.28 (0.89-1.84) b)

Table 4: McNemar's test for late USG impact on management decisions

Management Scenario	Number of Cases with change in management decision a) (n=28)	Percentage (%)	Risk Ratio (95% CI)	p-value
Surgical → Conservative	20	71.42%	0.40 (0.213- 0.752)	0.0013*
Conservative → Surgical	08	28.58%	1.00 (0.437- 2.289)	1.0000

Table 5: Organ injury detection rates by imaging modality

Organ Injury	CT Detection	E-FAST Detection	Late USG Detection	Diagnostic Agreement a)
Liver	19 (16/3)	16 (13/3)	5 (5/0)	κ = 0.78, P < 0.001*
Spleen	17 (11/6)	13 (8/5)	6 (3/3)	κ = 0.71, P < 0.001*
Kidney	9 (6/3)	8 (5/3)	2 (2/0)	κ = 0.82, P < 0.001*
Pancreas	7 (3/4)	7 (3/4)	1 (1/0)	κ = 0.85, P < 0.001*
Bowel	6 (0/6)	-	3 (0/3)	κ = 0.64, P = 0.002*
Bladder	4 (4/0)	2 (2/0)	1 (1/0)	κ = 0.66, P = 0.008*
Hemothorax	34 (28/6)	29 (24/5)	10 (7/3)	κ = 0.76, P < 0.001*
Pneumothorax	14 (11/3)	12 (9/3)	2 (1/1)	κ = 0.73, P < 0.001*
Hemoperitoneum	42 (26/16)	36 (23/13)	15 (7/8)	κ = 0.69, P < 0.001*
Pneumoperitoneum	12 (1/11)	-	7 (0/7)	κ = 0.62, P = 0.003*

Table 6: Follow-up outcome of trauma victims

Follow-up Course	Patient treated with Conservative Management (n=42)	Patient treated with Surgical management (n=28)	Overall Follow-up (n=70)	P-value a)	RR	95% CI (RR)
Uncomplicated follow-up course	33 (64.7 %)	18 (35.3 %)	51(72.8%)	0.0008*	1.55	[0.37- 6.5]
Complicated follow-up course	0	9 (100%)	9 (12.8%)	0.0005	0.0	[0.00- 0.95]

Lost to follow-up	9 (90 %)	1(10 %)	10 (14.4%)	0.363	0.44	[0.08- 2.38]

*Values are presented as numbers (%); RR, risk ratio; CI, Confidence interval; a) Results of Fisher's Exact Test; * P <0.05 (Statistically significant)*

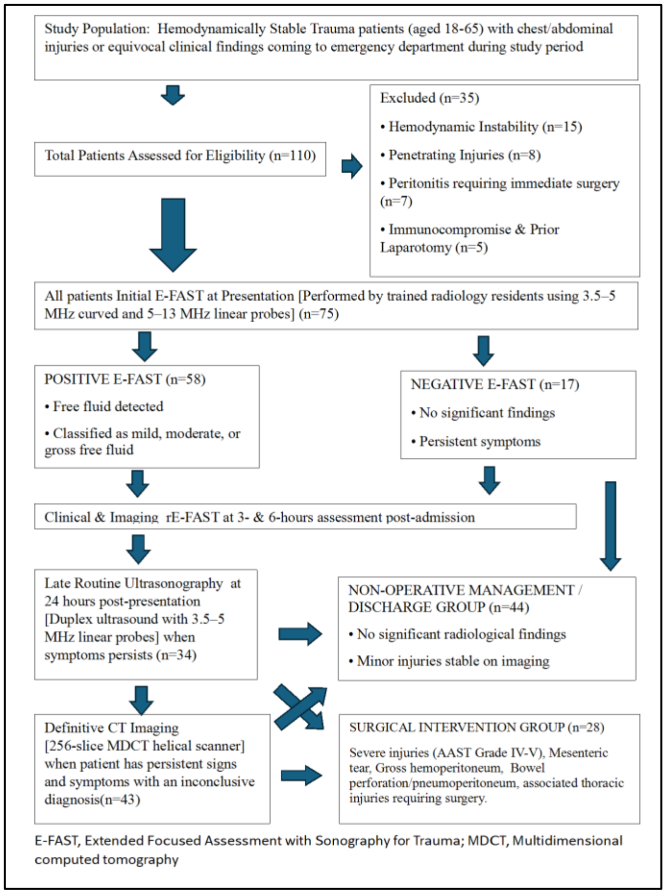

Figure 1: Diagnostic imaging study in blunt trauma victims (E-FAST, Extended Focused Assessment with Sonography for Trauma; CT, Computed tomography; rE-FAST, Repeated-FAST)

Discussion:

Using a prospective observational model, this study aimed to support ultrasound imaging modalities as a primary diagnostic tool in trauma management, potentially leading to changes in assessment paradigms that prioritise rapidity and patient safety, particularly in LMICs, where medical resources are inadequate. Correct management of blunt abdominal trauma should be based on clinical examination and hemodynamic stability of the patient in conjunction with radiological investigations **[7]**. CT is expensive and exposes patients to excessive radiation, limiting its access and further highlighting the need for alternative diagnostic methods, especially in hemodynamically stable patients **[8].** E-FAST ultrasound is the baseline, lowest cost modality; conventional ultrasonography costs about 2 to 4 times the cost of E-FAST (considering duration and operator involvement beyond initial FAST), while the CT scan costs, typically 10 to 20 times or more than E-FAST, reflecting high equipment costs, technical expertise and processing for patients **[9].** Our study supports the role of early E-FAST for detecting thoracoabdominal injuries in patients with blunt trauma. These findings are consistent with those of previous studies and emphasise the utility of E-FAST in these patients **[10].** Ultrasound imaging can be performed in the emergency room, eliminating transportation issues associated with hemodynamically unstable patients. Therefore, FAST has emerged as a point-of-care ultrasound modality **[11].** The possibility of performing ultrasound examinations serially to follow the evolution or resolution of trauma-related findings confers a further degree of flexibility in terms of safety and convenience, reducing the need for CT scans **[12].** E-FAST is a highly efficient tool for initial evaluation of a pneumothorax, as it provides immediate on-site imaging. The junction between sliding lung and absent sliding is known as the lung point and is nearly 100% specific for pneumothorax using E-FAST scans **[13].** E-FAST, combined with clinical examination, serves as a valuable triage tool for use in conjunction with resuscitation in trauma settings. CT scanning is the gold standard method for identifying intra-abdominal injuries in patients with blunt trauma, especially in those with high-energy trauma **[14].** Initial E-FAST scans are not performed to the patient's maximum ability and may miss some injuries that may become apparent as the patient develops worse clinical symptoms. rE-FAST is a real-time diagnostic tool that can be performed serially to observe symptom development or the emergence of new signs indicative of internal bleeding or other injuries. A previous study observed that the power of rE-FAST to exclude thoracoabdominal pathologies advanced over time. Sensitivity increases with the use of E-FAST, primarily if it is used repeatedly. E-FAST has 100% and 98.7% sensitivity and specificity for detecting thoracoabdominal haemorrhage in stable patients when repeated at 0, 3 and 6 h of follow-up **[15].** In patients with negative initial FAST but sustained abdominal symptoms, repeated sonography after 12–24 h can facilitate the diagnosis of gastrointestinal tract injury **[16]**. The sensitivity of ultrasound at presentation, 12 h and 24 h was 19.8%, 75.2% and 82.2%, respectively, showing an increasing pattern with repeated ultrasound examinations. This study reinforces the need for rE-FAST in conjunction with initial E-FAST and its influence on initial management, while acknowledging its limitations. Late USG in stable blunt abdominal trauma can be considered as secondary ultrasound; when combined with E-FAST, it is helpful for future conclusions and follow-up investigations. We performed late USG up to 24 h after admission because it allows for better visualisation of intraperitoneal fluid and superficial solid organ injuries, which can be visualised more clearly after the injury. Scanning the interloop space during a routine FAST may increase its sensitivity. The use of secondary Ultrasound indeed increases the ability of ultrasound to detect intraperitoneal fluid and intraperitoneal injury, as documented by the increase in sensitivity (72.13%) compared with the initial admission US sensitivity (31.14%, $p < 0.001$). Secondary ultrasound may provide clinical reassurance that significant hemoperitoneum is not present, thereby decreasing the chance of missing a significant intraperitoneal injury in these patients **[17].** A previous retrospective study showed that repeated sonography after 12 to 24 hours in patients with negative initial FAST but sustained abdominal symptoms can facilitate the diagnosis of gastrointestinal tract injury and can be an effective method instead of CT in developing countries **[18].** Patients were included only if initially stable, but surgical conversion often occurred when vital signs deteriorated *e.g.,* new-onset tachycardia, hypotension, or dropping haematocrit despite prior conservative treatment. Persistent or worsening abdominal tenderness, distension, rebound, or guarding were key indications for surgery, which accounted for eight patients with negative E-FAST results who were later operated upon due to evolving peritoneal irritation and tenderness on late USG findings **[19]**. The study emphasised dynamic re-evaluation every 3–6 hours (rE-FAST and late USG) not only for imaging follow-up but also for monitoring symptom progression (pain escalation, vomiting, or distension). In statistical analysis, imaging findings were correlated with management outcomes (*e.g.,* E-FAST free-fluid levels and surgical rates, $p = 0.001$); however, clinical deterioration was not excluded as a confounding variable. Follow-up observations showed that patients managed conservatively (based on negative or mild ultrasound findings) generally had favourable outcomes, suggesting that the initial management decisions were appropriate and effective. However, the loss to follow-up underscores the need for structured monitoring systems, particularly for high-risk patients. A hybrid approach combining E-FAST for initial triage, Late USG for dynamic monitoring and CT for definitive diagnosis optimises the diagnostic accuracy and patient management, balancing speed, safety and precision. CT remains the gold standard, especially for complex injuries in the retroperitoneum and hollow viscera, areas where ultrasound's sensitivity is suboptimal. E-FAST, as a single technique, have several limitations. Ultrasound imaging modalities may not be as helpful in detecting certain types of injury, such as retroperitoneal injuries (*e.g.,* pancreatic or renal injuries) located posterior to the abdomen, minor slow-bleeding injuries that may have no detectable source of hemorrhage on ultrasound and solid organ injuries where subtle or minor lacerations may remain undetected without CT imaging **[20].** rE-EFAST may require additional procedural time in comparison with EFAST; it is highly dependent on the experience of the physician (a good FAST exam takes only 30 seconds)**.** Inaccuracies in interpretation, patient positioning, or anatomic changes can also contribute to inconsistent findings on repeat imaging, potentially leading to overestimation or underestimation **[21]**. Training programs should focus on technical skills. It is challenging to generalize these results when a single tertiary care center serves as the sole study site, as the small numbers of certain types of injuries (*e.g.,* bowel or bladder injuries) reduce statistical power for conclusive results.

Conclusion:

We show that the capability of ultrasound imaging modalities to rule out thoracoabdominal injuries, offering the advantage of being less time- and resource-intensive. When combined, repeated ultrasound imaging modalities have been shown to achieve sensitivities similar to those of CT scans for thoracic injuries and comparable sensitivities for abdominal injuries. Thus, further investigate the incorporation of ultrasound imaging modalities into standard clinical protocols, evaluate promising outcomes and enhance trauma care.

Advancement to Knowledge:

This study advances current knowledge by providing comparative evidence on the effectiveness of ultrasound imaging modalities and computed tomography scan findings in the evaluation of blunt thoracoabdominal trauma victims. It highlights the usefulness of ultrasound as a rapid and accessible diagnostic tool in emergency settings and its role in supporting timely surgical decision-making, thereby contributing to improved trauma management and patient care.

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