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ORIGINAL ARTICLE

The Diagnostic Value of Focused Assessment with Sonography for Trauma Ultrasound in Children with Blunt Abdominal Trauma: Assessing Accuracy and Clinical Utility

Amir Rahmanian Sharifabad[1], Farnood Forouhar[2] ✉, Leila Ghafoor[3], Hossein Akbari[1], Elhamsadat Mousavi[1]

[1] *School of Medicine, North Khorasan University of Medical Sciences, Bojnurd, Iran*

[2] *Department of Surgery, Trauma Research Center, Kashan University of Medical Sciences, Kashan, Iran*

[3] *Department of Biostatistics and Epidemiology, Kashan University of Medical Sciences, Kashan, Iran*

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Abstract

Introduction: Understanding the strengths and limitations of imaging techniques is essential for accurate diagnosis and optimal management of patients with blunt abdominal trauma. This study assessed the diagnostic accuracy of Focused Assessment with Sonography for Trauma (FAST) ultrasound in pediatric blunt abdominal trauma.

Methods: This retrospective study analyzed the medical records of 314 pediatric patients from the trauma center at Shahid Beheshti Hospital, Kashan, Iran. Demographic data, FAST results, and computed tomography (CT) findings were collected and interpreted by a radiologist. The obtained data were analyzed using the Chi-square test or Fisher's exact test. Moreover, SPSS software (version 16) was used to examine sensitivity and specificity, as well as positive and negative predictive values. A p-value of 0.05 was considered statistically significant.

Results: CT scans showed abnormalities in 70% of patients, with 154 (70%) male patients. No significant association of trauma mechanism, gender, age, and Glasgow Coma Scale (GCS) scores with CT results (P>0.05) was found in this study. However, abdominal tenderness was associated with CT results (P=0.004). Abnormal FAST correlated with abnormal CT (P<0.001). FAST demonstrated significant diagnostic value in pediatric blunt abdominal trauma, and abdominal tenderness emerged as a relevant indicator.

Conclusion: FAST can be a valuable initial screening tool, aiding in timely and accurate management decisions for patients with blunt abdominal trauma. Further investigation is needed to explore factors influencing the correlation between FAST and CT in critically ill patients with GCS<13.

Key words: Abdominal Injuries, Computed Tomography, Focused Assessment with Sonography for Trauma, Pediatrics

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Introduction

Blunt abdominal trauma is a common presentation in the emergency department and can result in significant morbidity and mortality if not promptly identified and managed. Accurate and timely diagnosis of intra-abdominal injuries is crucial for appropriate patient care. Various

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Tel: +985632381214
Fax: +985632440488
Po Box 97175-379
Email: jsurgery@bums.ac.ir

✉ **Correspondence to:**
Farnood Forouhar, Department of Surgery, Trauma Research Center, Kashan University of Medical Sciences, Kashan, Iran;
Telephone Number: +989155058127
Email Address: drfarnood63@gmail.com

imaging modalities have been utilized to evaluate blunt abdominal trauma, including ultrasound and computed tomography (CT). The selection of an optimal imaging approach depends on such factors as diagnostic accuracy, availability, cost-effectiveness, and radiation exposure.

Numerous studies have investigated the utility of ultrasound in the assessment of blunt abdominal trauma. Holmes et al. conducted a prospective evaluation of criteria for obtaining thoracolumbar radiographs in trauma patients, highlighting the importance of focused assessment with sonography for trauma (FAST) as a reliable tool for identifying intra-abdominal injuries (1). Another study by Holmes et al. focused on identifying children at very low risk of clinically important blunt abdominal injuries, emphasizing the role of clinical assessment and ultrasound in the management of pediatric patients (2).

Nayak et al. conducted a review study evaluating the use of ultrasonography in blunt abdominal trauma, demonstrating its effectiveness in detecting free fluid and solid organ injuries (3). Riera et al. performed an original article and meta-analysis, supporting the utility of FAST in pediatric abdominal trauma and emphasizing its potential to improve diagnostic accuracy and patient outcomes (4). Bahrami-Motlagh et al. conducted a similar original article and meta-analysis, further validating the accuracy of FAST in blunt pediatric abdominal trauma (5).

In addition to ultrasound, CT has emerged as a valuable imaging modality in the evaluation of blunt abdominal trauma. Khan et al. compared ultrasound and CT in a prospective study, highlighting the diagnostic performance and utility of CT in identifying intra-abdominal injuries (6). The performance of abdominal ultrasonography in blunt trauma patients with out-of-hospital or emergency department hypotension was examined by Abdolrazaghinezahd et al., indicating its limitations in certain clinical scenarios (7). However, a meta-analysis conducted by Liang et al. demonstrated the overall performance and accuracy of abdominal ultrasonography in blunt trauma patients (8).

Other studies have focused on the role of imaging modalities specific to pediatric populations. Achatz et al. emphasized the importance of rapid assessment of blunt abdominal trauma in pediatric emergency departments, underscoring the need for appropriate imaging strategies (9). Ullah et al. conducted a systematic review and meta-analysis, evaluating the diagnostic performance of surgeon-performed FAST in pediatric blunt trauma patients (10). Sargent et al. conducted a systematic review and meta-analysis specifically on FAST in children, further highlighting its diagnostic accuracy and utility (11). Moreover, the detection of specific injuries and findings related to blunt abdominal trauma has been investigated. Saleh et al. conducted a systematic review and meta-analysis, focusing on the sonographic detection of pneumoperitoneum in patients with blunt abdominal trauma (12).

Wurmb et al. highlighted the role of whole-body multislice CT as the first-line diagnostic tool in patients with multiple injuries, emphasizing the importance of timely imaging (13). Gupta et al. explored the role of CT in the evaluation of abdominal trauma, discussing its advantages and limitations (14). Chien et al. compared CT findings with the American Association for the Surgery of Trauma Organ Injury Scale in pediatric blunt abdominal trauma and highlighted the correlation between imaging findings and organ injury severity (15).

In summary, the evaluation of blunt abdominal trauma requires careful consideration of various imaging modalities, such as ultrasound and CT. Multiple studies have assessed the diagnostic accuracy and utility of these modalities in detecting intra-abdominal injuries. The findings suggest that ultrasound, particularly FAST, plays a vital role in the initial evaluation of blunt abdominal trauma, while CT is valuable for identifying specific injuries and providing detailed anatomical information. Understanding the strengths and limitations of these imaging techniques is essential for accurate diagnosis and optimal management of patients with blunt abdominal trauma. This article aims to assess the diagnostic accuracy and clinical utility of FAST ultrasound in pediatric blunt abdominal trauma, with a focus on its potential role as an initial screening tool.

Methods

This retrospective study aimed to determine the diagnostic value of FAST ultrasound in pediatric patients with blunt abdominal trauma. The study utilized medical records from a trauma center at Shahid Beheshti Hospital, Kashan, Isfahan, Iran, from 2017 to 2019.

The inclusion criteria for the study were all patients referred to Shahid Beheshti Hospital, Kashan, Isfahan, Iran, who were under 18 and underwent FAST in the Emergency Department (ED) followed by abdominopelvic CT with IV-contrast evaluation. On the other hand, the patients with the first evaluation done more than 24 hours after the trauma and those with a history of previous intra-abdominal surgery were excluded from the study.

The data for this study were collected from the

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hospital's electronic medical records system. The demographic information, including age and gender, was recorded for all included patients. Additionally, clinical data, such as trauma mechanisms and Glasgow Coma Scale (GCS) scores, were documented.

FAST examinations were performed by a specific Emergency Medicine specialist for all included patients. Abnormal FAST results were defined as the presence of free fluid in any of the intraperitoneal spaces (hepatorenal, splenorenal, or perivesical).

CT scans were interpreted by a specific radiologist, and CT results included the presence of free fluid in intraperitoneal spaces and other intra-abdominal organ injuries, such as spleen, liver, small intestine, and kidneys.

The statistical analysis was performed using SPSS software (version 16). Descriptive statistics were used to summarize the demographic data of the study population, and the distribution of patients based on their GCS scores was presented. The relationship of gender, trauma mechanisms, age, and GCS scores with CT results was analyzed using the Chi-square test or Fisher's exact test, as appropriate. In this study, statistical significance was determined at a significance level of 5% ($P<0.05$). Therefore, p-values less than 0.05 were considered statistically significant.

To investigate the association between FAST and CT results, the number of cases with abnormal and normal FAST findings was compared with the presence or absence of intra-abdominal injuries on CT scans using the Chi-square test.

A subgroup analysis based on GCS scores was conducted to explore further the correlation between abnormal FAST and abnormal CT results.

In the discussion section, potential factors contributing to the lack of correlation between abnormal FAST and CT results in patients with GCS<13 were discussed, including technical challenges, clinical priorities in severely injured patients, and the complexity of injuries in patients with severe neurological impairment.

Overall, this study provides valuable insights into the diagnostic value of FAST in pediatric blunt abdominal trauma and emphasizes the importance of considering various clinical factors when interpreting FAST results in critically ill patients.

The research protocol was reviewed and approved by the Institutional Review Board of Kashan University of Medical Sciences, Kashan, Iran. The ethical code for this study is IR.KAUMS.MEDNT.REC.1398.005.

Results

A total of 314 patients were included in the study, according to the predefined inclusion criteria, and regarding gender, the majority of patients were male (n=223, 71%) (Table 1). Out of the total CT cases, 220 CT scans revealed pathologic findings, such as free fluid or intra-abdominal injuries. Among these cases, 154 (70%) patients were male. On the other hand, among the patients with normal CT scans, 76.6% of the cases were male. However, statistical analysis (Chi-squared test) revealed no significant relationship between gender and CT results ($P=0.209$).

Trauma mechanism also showed no statistically significant association with CT results ($P=0.59$). Among the patients with abnormal CT scans, 36 cases were associated with car accidents, 38 cases with pedestrian-vehicle accidents, and 26 cases with falling incidents. In the normal CT group, 84 cases were related to car accidents, 98 cases to pedestrian-vehicle accidents, and 32 cases to falling incidents.

The analysis of age in relation to CT results showed no statistically significant correlation ($P=0.072$). The average GCS score for patients with abnormal CT scans was 14.3±1.28, while it was 13.71±2.34 for patients with normal CT scans. Similarly, no significant relationship was observed between the initial estimated GCS score and CT results ($P=0.188$). Nausea and vomiting were not found to be associated with CT results ($P=0.536$ and $P=0.148$, respectively). However, the presence of abdominal tenderness was significantly related to CT results ($P=0.004$).

When comparing the CT results with surgical findings, significant associations were observed. In patients with abnormal CT scans, 37 cases showed spleen injuries, 21 cases had liver injuries, 6 cases had small intestine injuries, and 2 cases had kidney injuries, all of which were confirmed during surgical exploration ($P<0.001$ for spleen and liver injuries, $P<0.005$ for small intestine injuries, $P<0.595$ for kidney injuries). However, no statistically significant relationship was found between hemodynamic stability and CT results ($P=0.094$).

Furthermore, the accuracy of FAST in predicting CT results was evaluated. In cases where the CT scan was abnormal, FAST was abnormal in 57 cases (49 male, 8 female), and normal in 36 cases (16 male, 20 female). In cases where the CT scan was normal, FAST was abnormal in 5 cases (2 male, 3 female), and normal in 216 cases (166 male, 50 female). The observed association between CT results and FAST findings was statistically significant ($P<0.001$).

Finally, the performance of FAST in predicting CT results was assessed based on different factors.

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Table 1: Age, GCS, mechanism of injury, and relative abundance according to gender

Demographic Characteristics	Total Patients (n=314)	Male (n=223)	Female (n=81)
Age (years)			
- Under 6	84 (26.8%)	53 (23.8%)	31 (38.3%)
- 6 and older	230 (73.2%)	170 (76.2%)	60 (74.1%)
Glasgow Coma Scale (GCS)			
- <13	22 (7.0%)	4 (1.8%)	18 (22.2%)
- 13-15	292 (93.0%)	219 (98.2%)	73 (90.1%)
Mechanism of Injury			
- Car Accident	120 (38.2%)	84 (37.7%)	36 (44.4%)
- Pedestrian-Vehicle	136 (43.3%)	98 (44.1%)	38 (46.9%)
- Falling	58 (18.5%)	41 (18.4%)	17 (21.0%)

Table 2: FAST sensitivity and specificity in detecting intra-abdominal injury

Subgroup	FAST Sensitivity (%)	FAST Specificity (%)	FAST NPV (%)	FAST PPV (%)
Total	59.7	89.4	90.1	54.4
Gender (Male)	79.3	18.7	67.9	30.0
Gender (Female)	20.5	81.3	76.9	27.0
Age (<6 years)	74.5	26.1	72.9	27.6
Age (≥6 years)	48.6	93.5	89.5	57.1
GCS (13-15)	62.3	95.9	86.5	81.0
GCS (<13)	24.1	97.4	83.3	66.7

NPV: Negative Predictive Value
PPV: Positive Predictive Value
GCS: Glasgow Coma Scale

The negative and positive predictive values, specificity, and sensitivity of FAST in predicting CT results were calculated overall and for specific subgroups.

In summary, the study findings suggest that FAST is a valuable tool for detecting abdominal injuries in children with blunt abdominal trauma. It showed good specificity and positive predictive value overall and across different subgroups. However, its sensitivity and negative predictive value varied based on factors, such as gender, age group, and GCS score (Table2).

Discussion

The present study aimed to assess the diagnostic value and clinical utility of FAST ultrasound in pediatric patients with blunt abdominal trauma. Our findings revealed that the presence of free fluid detected by FAST was significantly associated with abnormal CT results, indicating intra-abdominal hemorrhage, in the overall study population. This observation aligns with previous studies that have demonstrated the accuracy and efficacy of FAST in diagnosing abdominal injuries (8, 6, 3).

Interestingly, when examining specific subgroup-based GCS scores, we observed a distinct trend. In pediatric patients with GCS<13, the relationship between FAST findings and abnormal CT results was not statistically significant (P=0.855). This may indicate that in cases of more severe traumatic brain injury, the presence of free fluid detected by FAST may not reliably correlate with intra-abdominal injuries. It is crucial for clinicians to be cautious when interpreting FAST results in patients with severe neurological impairment, as these patients may exhibit atypical FAST findings despite having significant intra-abdominal injuries.

In contrast, in pediatric patients with GCS scores between 13 and 15, FAST remained a valuable tool for detecting intra-abdominal injuries, with a statistically significant relationship between abnormal FAST and abnormal CT results (P<0.001). This supports the use of FAST as an initial screening tool in alert and responsive patients with less severe neurological impairment, where it can aid in prompt and accurate identification of abdominal injuries.

Our study also explored the relationship between demographic characteristics and CT results in conjunction with FAST findings. Gender, age, and trauma mechanism did not show any statistically significant association with CT results. However, the presence of abdominal tenderness was significantly related to abnormal CT results, suggesting that clinical examination findings can complement the diagnostic accuracy of FAST.

It is essential to interpret the findings of this study in the context of its limitations. As a retrospective analysis, potential selection bias and missing data might have influenced the results. Additionally, the study focused on a specific pediatric population from a single trauma center, limiting its generalizability to other settings. Future

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prospective studies with larger and more diverse patient cohorts would help to validate and further refine the findings presented here.

Our study highlights the significant diagnostic value of FAST ultrasound in pediatric patients with blunt abdominal trauma, particularly in those with GCS scores between 13 and 15. However, caution should be exercised when interpreting FAST findings in patients with severe neurological impairment (GCS<13), as the relationship between FAST results and abnormal CT findings was not statistically significant in this subgroup. FAST remains a valuable initial screening tool, but its interpretation should consider the patient's neurological status to avoid potential diagnostic pitfalls. The integration of FAST with other clinical and radiological assessments can aid clinicians in making accurate and timely decisions for the management of pediatric patients with blunt abdominal trauma.

Conclusions

In our retrospective analysis of 314 pediatric blunt abdominal trauma cases, we found no statistically significant associations of gender, trauma mechanism, age, and initial GCS with CT results. However, abdominal tenderness correlated with abnormal CT findings, particularly for spleen and liver injuries requiring surgery. FAST ultrasound performed well, with higher sensitivity in males and older children (≥6 years) and higher specificity in females and younger children (<6 years). FAST's notable negative predictive value suggests its potential for excluding significant abdominal injuries. While supporting FAST's utility in pediatric trauma, further studies are needed to define its precise role alongside confirmatory imaging like abdominopelvic CT with IV contrast.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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