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ORIGINAL ARTICLE

FAST versus F-AST Score (FAST plus Aspartate Transaminase) in Pediatric Blunt Abdominal Trauma — a Case Series Analysis

Ankit Kumar Sahu[1] · Sanjeev Bhoi[2] · Srikanth Elambilakatt Raroth[1] · Praveen Aggarwal[1] · Roshan Mathew[1] · Tej Prakash Sinha[2] · Suprith C[3]

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Abstract

The use of focused assessment with sonography for trauma (FAST) examination in pediatric blunt abdominal trauma (BAT) has not been well accepted because of its poor sensitivity. We aim to determine whether the FAST combined with elevated liver enzymes, i.e., aspartate transaminase (AST), could be used as a better screening tool for intra-abdominal injury (IAI) in pediatric BAT and develop a new prediction model.

A case series analysis was performed among pediatric patients (age < 18 years) with BAT, presenting to a level-1 trauma center. Data on patient demographics, vital signs, mechanism of injury, FAST finding, contrast-enhanced computed tomography (CECT) scan of the abdomen, and serum AST levels, were collected. Multiple logistic regression (MLR) was used to develop a prediction model for IAI.

Overall, 499 children were identified. FAST was positive in 72 patients, whereas 69 patients had IAI in a CECT. FAST alone had a sensitivity of 76.8%. FAST examination's negative predictive value (NPV) and negative likelihood ratio (NLR) were 95.8% and 0.24, respectively. Combining FAST and AST levels led to an increase in sensitivity to 91.3%, NPV to 97.9%. The NLR decreased to 0.1, which was clinically more relevant. In the MLR model, the odds ratios for the presence of IAI were significant for FAST and AST levels. Hence, FAST and AST levels were included in the new 'F-AST score'. A score of one was assigned for FAST positive and zero for FAST negative. AST level < 90 U/L was assigned a score of zero and > 90 U/L as one. Aggregate F-AST score ranged from 0 to 2. The receiver's operating characteristics (ROC) analysis showed the F-AST score to be very accurate with an area under the ROC curve of 0.905.

Pediatric patients with a F-AST score of 0 (negative FAST and AST < 90 U/L) may be observed rather than subjected to CT scan radiation risk.

Keywords Pediatric trauma · Blunt abdominal injury · FAST examination · Serum transaminase · Diagnostic accuracy

✉ Sanjeev Bhoi
sanjeevbhoi@gmail.com

Ankit Kumar Sahu
ankitkumarsahu13@gmail.com

Srikanth Elambilakatt Raroth
ersrikanth1@gmail.com

Praveen Aggarwal
peekay_124@outlook.in

Roshan Mathew
roshmat15@gmail.com

Tej Prakash Sinha
drsinha1234@gmail.com

Suprith C
c.suprith@gmail.com

1 Department of Emergency Medicine, All India Institute of Medical Sciences, New Delhi, India

2 Department of Emergency Medicine, Jai Prakash Narayan Apex Trauma Center, All India Institute of Medical Sciences, New Delhi, India

3 Department of Critical Care, Apollo Speciality Hospital, Jayanagar, Bangalore, India

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Background

Trauma is the leading cause of morbidity and mortality in pediatric population of all ages [1]. Evaluation of the injured children for intra-abdominal injuries (IAI) may be difficult because of their inability to communicate [2]. Hence, the diagnosis of IAI in children is difficult but necessary to prevent complications. Although computed tomography (CT) abdomen is a diagnostic test of choice to detect IAI in blunt abdominal trauma (BAT), it has its own disadvantages. It may require pharmacologic sedation, administration of intravenous contrast, substantial radiation exposure and transport out of the controlled environment of emergency department (ED) [3, 4]. Focused assessment with sonography for trauma (FAST) has been integrated in the management of adult trauma patients because of its point-of-care application, no radiation exposure, and ability to repeat assessments [5]. However, its use in children is controversial, with some studies supporting its use [6, 7] and others questioning its utility [8, 9]. A recent meta-analysis showed FAST to be only 35% sensitive and 96% specific in diagnosing IAI in pediatric patients [10].

A few algorithms have been developed to increase the diagnostic accuracy of FAST in pediatric BAT like the integration of liver transaminase and physical examination with FAST findings [11, 12]. Liver enzymes like aspartate transaminase (AST) are elevated in pediatric BAT patients with IAI even in the absence of hepatic injury and have been shown to be an important predictor of IAI in pediatric BAT [11, 12]. We sought to determine whether FAST combined with AST level could obviate the need for an abdominal CECT scan, and to develop a novel clinical prediction rule to avoid CECT scan in pediatric BAT.

Methods

This study was approved with a waiver of consent by the Institution Ethics Committee of All India Institute of Medical Sciences (AIIMS), New Delhi, India.

Study Design, Setting, and Population

A case series analysis (from year January 2017 to December 2019) was performed among pediatric patients (age ≤ 18 years), presenting to the Level-1 trauma center (Jai Prakash Narayan Trauma Centre, AIIMS, New Delhi, India). The study included all patients with a blunt trauma of abdomen who were evaluated with both CT scan and FAST at admission. Patients who were transferred from other hospitals or presented in cardiac arrest were excluded.

Data Collection

The retrospective electronic health record query yielded data on patient demographics (age, gender), initial vital signs, mechanism of injury, time lapse from injury to admission in ED (in hours), and physical examination findings (abdominal inspection, palpation to elicit tenderness, percussion and auscultation; pelvic compression test; and renal angle tenderness). FAST findings, CECT abdomen findings (IAI details) and serum AST levels were included. FAST was performed in the ED by emergency physicians. Positive FAST examination was defined as the presence of free fluid in the abdomen on FAST scan. The CECT abdomen findings were interpreted and reported by radiologists and considered gold standard for comparison with FAST and the newly developed score.

Statistical Analysis

Counts and percentages were used to summarize categorical data. Mean and standard deviation (SD) were used to summarise normally distributed data, whereas median, range and interquartile range (IQR) were used to summarize non-normal continuous data. The primary outcome was the presence of IAI in CECT scan. Sensitivity, specificity, positive predictive value, negative predictive value, positive and negative likelihood ratios were calculated for FAST, and combination of FAST and AST level. Serum AST level was dichotomized by defining its optimum cut-off using Youden's-J statistics on the receiver's operating characteristics curve (ROC) for presence of IAI in CECT.

Multiple logistic regression (MLR) using relevant demographic, clinical, and laboratory criteria was utilized for the prediction of IAI. These include continuous covariates like age, time lapse since injury to admission, systolic blood pressure, Glasgow Coma Score (GCS); and categorical covariates like gender, mechanism of injury (fall from height, others), FAST findings (positive, negative) and serum AST levels (≤90U/L, > 90U/L). Favoring simplicity over accuracy, a point score of 1 was assigned to each variable in the final model, irrespective of the regression coefficients. Model calibration was assessed by Hosmer–Lemeshow test and Pearson $\chi 2$ was applied to compare observed counts with expected counts. Area under the ROC curve (AUROCs) was calculated for the new prediction score including FAST and above-mentioned covariates which were significant in MLR. All analyses were performed with IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY: IBM Corp. All tests of significance used a 2-sided p-value ≤ 0.05. We considered AUROCs to be poor if it is ≤ 0.70, adequate at 0.71 to 0.80, good at 0.81 to 0.90, and excellent at ≥ 0.91.

Results

A total of 499 children met the inclusion criteria. The mean age was 8.5 years (SD: 5.9), with 66.1% (297 out of 449) being male patients. Most injuries were due to fall from height in 62.1% patients, followed by road traffic crash in 31.6% of patients. Mean time to reach the ED from injury was 4.9 h. Most patients were hemodynamically stable on presentation. FAST was positive in 16.0% (n = 72) of all patients. Findings of the FAST examination are summarized in the **Supplementary Table** 1. Median AST level was 65 U/L (range: 10–2554). Sixty nine out of 449 patients (15.4% of all patients) had IAI in CECT scan. Liver was the most injured organ (n = 33), followed by spleen (n = 13) (**Supplementary Table** 2 and 3). The demographics and clinical characteristics are shown in **Table 1**.

Table 1 Demographics and clinical characteristics of included patients

Characteristics	n = 449
Age, % (n)	
0–5 years	43.2 (194)
6–10 years	21.4 (96)
11–18 years	35.4 (159)
Gender, % (n)	
Male	66.1 (297)
Female	33.9 (152)
Mechanism of injury, % (n)	
Fall from height	62.1 (279)
Road traffic crash	31.6 (142)
Assault	4.1 (19)
Near drowning	0.4 (2)
Others	1.6 (7)
Vitals at presentation (mean ± SD)	
Systolic blood pressure (in mmHg)	110 ± 18
Diastolic blood pressure (in mmHg)	70 ± 11
Heart rate (per min)	104 ± 23
Respiratory rate (per min)	19 ± 4
FAST finding, % (n)	
Positive	16 (72)
Negative	84 (377)
CECT findings, % (n)	
Intra-abdominal injuries present	15.4 (69)
Intra-abdominal injuries absent	84.6 (380)

Diagnostic Statistics

The FAST was positive (i.e., presence of free fluid in the abdomen) in 53 out of 69 patients with IAI found in CT scan, led to a sensitivity of 76.8%. The FAST was negative (i.e., absence of free fluid in the abdomen) in 361 of the 380 patients with negative CT scans (i.e., absence of IAI) for a specificity of 95%. The PPV, NPV, PLR and NLR of FAST examination were 73.6%, 95.8%, 15.4, and 0.2, respectively. The ROC curve analysis revealed the optimal cut-off value of 90 U/L for AST using the Youden's-J index **(Supplementary Fig. 1).** We conducted the diagnostic accuracy analysis of combined FAST and AST level, where the combination was considered negative in patients having both FAST was negative and AST ≤ 90 U/L, whereas all other patients were considered positive. This combination led to increase in sensitivity to 91.3% and NPV to 97.9%. The NLR decreased to 0.1. There were decreases in specificity to 75.0%, PPV to 39.9% and PLR to 3.7 **(Table 2).**

Development of F-AST Score

Adjusting for all the other variables in the multiple logistic regression models, the odds ratios for presence of IAI on CECT scan of abdomen were significant for FAST and AST levels only, as shown in **Table 3.** Hence, only FAST findings and AST levels were included in this new F-AST score. A score of one was assigned for FAST positive and zero for FAST negative. AST level less than or equal to 90 U/L was assigned a score of zero and more than 90 U/L as one. Aggregate F-AST score ranged from 0 to 2. Among the 291 patients who had F-AST score of zero, 285 patients (97.9%) did not have any IAI on CECT scan of abdomen (**Table 4).** To find out the accuracy of F-AST score in predicting IAI, ROC analysis was conducted and found to be excellently

Table 2 Diagnostic accuracy statistics of FAST, and combination of FAST and AST level in screening intra-abdominal organ injuries as compared to computed tomography of abdomen

	FAST alone	Combination of FAST and AST level
True positive	53	63
False positive	19	95
False negative	16	6
True negative	361	285
Sensitivity	76.8	91.3
Specificity	95	75
Positive predictive value	73.6	39.9
Negative predictive value	95.8	97.9
Positive likelihood ratio	15.36	3.65
Negative likelihood ratio	0.24	0.12

Table 3 Result of multiple linear regression showing odds ratio for different covariates predicting presence of intra-abdominal injuries in computed tomography of abdomen

Covariates	OR (95% CI)	*p-value*
Age	1.053 (0.971, 1.140)	0.204
Gender*	0.975 (0.378, 2.517)	0.958
Time lapse from injury to admission	1.034 (0.958, 1.116)	0.385
Mechanism of injury*	2.381 (0.904, 6.270)	0.079
Systolic blood pressure	1.000 (0.976, 1.024)	0.984
Glasgow coma score	0.972 (0.865, 1.093)	0.636
AST level*	8.99 (3.784, 21.356)	< 0.001
FAST status	46.22 (19.41, 110.0)	< 0.001

Footnote: * shows covariates which are considered as categorical variables in multiple logistic regression

Table 4 Proportion of patients with intra-abdominal injuries in each F-AST score subsets of patients

	Intra-abdominal organ injuries (CECT abdomen)		
F-AST score*	Absent, n (%)	Present, n (%)	Total, n (%)
0	285 (97.9)	6 (2.1)	291 (100)
1	91 (82)	20 (18)	111 (100)
2	4 (8.5)	43 (91.5)	47 (100)

Footnote: * F-AST score consists of addition of individual score of FAST finding (positive – 1, negative – 0) and AST level (> 90 U/L – 1, < 90 U/L – 0)

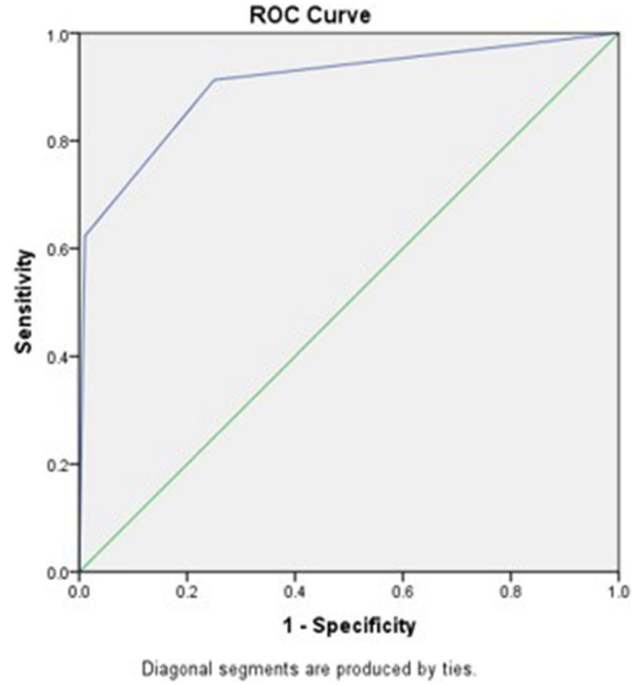

Fig. 1 **Receiver's operating characteristics curve for F-AST score for predicting intra-abdominal organ injuries in computed tomography of abdomen.** Footnote: Area under ROC is 0.905 with 95% CI: 0.859–0.950 (p < 0.001). AUROC > 0.9 is considered as excellently accurate

accurate (AUROC – 0.905, 95%CI: 0.859–0.950, *p < 0.001*) **(Fig. 1).**

Discussion

Our study has shown that FAST was 76.8% sensitive in diagnosing IAI, whereas combining FAST and AST levels significantly increased the sensitivity to 91.3%. More importantly, this combination had increased the NPV to approximately 98% and decreased the NLR nearly to 0.10. Hence, patients with a negative FAST examination and AST </=90U/L may be safely observed in ED without an immediate CT scan. In addition to this, F-AST score was derived, which was found to be excellently accurate in the predicting IAI. This novel score works as a prediction model for obviating the need of immediate CT scan in the subset of patients with a score of 0.

Most of the studies including ours, demonstrated that pediatric FAST is less sensitive for detection of IAI [8, 10, 13]. Holmes et al. conducted a prospective observational study on pediatric BAT and identified six factors associated with IAI among which raised liver enzymes were found to be the highest predictor of IAI (OR – 17.4, 95% CI: 9.4–32.1) [2]. Similar studies found that raised liver enzymes predict IAI [3, 14, 15]. Since then, to increase the diagnostic accuracy of FAST, the role of integration of liver enzymes, physical finding and vital signs have been investigated [11, 12].

Sola et al. had conducted a retrospective study on 400 pediatric BAT patients and found that, there was an increase in the sensitivity from 50.4% with FAST alone to 96.1% with combination of FAST and liver enzymes > 100 U/L (arbitrary cut-off) [11]. Our study has also shown a similar finding, except that we have used the AST cut-off as 90 U/L (derived from ROC analysis and Youden's—J statistics) and also demonstrated a decrease of NLR, which is clinically more relevant. In contrast to the study conducted by Sola et al. [11], there was a decrease in specificity, PPV and PLR when FAST was combined with AST level, in our study. This can be explained by the fact that combining tests in parallel improves the negative predictive value, as it increases the sensitivity and reduces false negatives [16].

Zeeshan et al. had incorporated physical finding with FAST and liver enzymes and demonstrated an increase in diagnostic accuracy of combined tests [12]. However, in our study, we have not included physical examination except for initial vital signs as a covariate because these findings are based on the patient's ability to communicate that can be limited in pediatric settings especially with altered sensorium or the presence of distracting injuries, and an examiner's expertise to demonstrate a clinical sign [2, 17].

We derived an objective prediction rule that risk stratifies children for IAI following BAT, i.e., F-AST score (combination of FAST finding and AST levels). As shown in **Table 4**, 97.9% of patients with F-AST score 0 had no IAI. Patients with F-AST score of 1 (18.0% had IAI) and 2 (91.5% had IAI) had significantly higher proportion of IAI than that of with 0. We, therefore, suggest that patients with F-AST score of 0, which is negative FAST examination and AST level ≤ 90 U/L may be observed in the ED.

Limitations

This is a single-centered case series analysis; hence, generalization is questionable. Clinical decision making based on laboratory values has a disadvantage of the delay waiting for the results. Although the turnover time for getting AST results is 1 h whether this waiting time is worthy of observing or sending the patient for CECT scan is to be addressed separately in future studies. We did not collect the information on the final injury pattern found in the laparotomy and the ultimate outcome like survival, hence, could not assess the association of these with FAST findings. Future studies are needed with incorporation of these pragmatic endpoints.

Conclusion

Adding AST values significantly improves the sensitivity and reduces the negative likelihood ratio of FAST examination. Thus, it can help in preventing unnecessary radiation exposure from CT scan in the pediatric population with blunt abdominal trauma. As the study population was a derivation cohort, further prospective validation studies are warranted to support our results.

Availability of data

All information regarding the study can be obtained from the corresponding author on appropriate request.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12262-022-03338-y.

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Study design – AK, SC, TS
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Data analysis – AK
Data interpretation – SB, PA, TS, RM
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Critical revision – SB, PA, TS

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Declarations

Conflict of interest The authors declare no competing interests.

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