



# The association between intra-abdominal injury and clinical, imaging, and laboratory findings in children with blunt abdominal trauma: A cross-sectional study

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## Abstract

**Background:** Blunt abdominal trauma (BAT) is one of the major causes of mortality and morbidity, and its diagnosis and treatment are still challenging.

**Objectives:** This study aimed to evaluate the association between intra-abdominal injuries and clinical, imaging, and laboratory findings in children with BAT.

**Methods:** This cross-sectional study evaluated children diagnosed with BAT who were candidates for computed tomography (CT) of the abdomen and pelvis referred to the level-1 trauma center of Hashminejad, Taleghani, and Emdadi Hospitals of Mashhad. The demographic information, results of physical examination, CT, Sonography for Trauma (FAST), vital signs, and laboratory tests were recorded.

**Results:** A total of 96 children with BAT, with a median age of 10.5 (Q1, 8, Q3, 13), were enrolled. Organ injury was observed in 33% of patients on CT, 20% on FAST, and 54% on physical examination. Moreover, abnormal amylase, lipase, ALT, and AST were found in 23%, 12%, 31%, and 34% of cases, respectively. The abnormal levels of amylase and lipase showed 91.3% and 52% sensitivity, 97% and 100% specificity, and an AUC of 0.99 (95% CI 0.975-1.00) and 0.973 (95% CI 0.947-0.99), respectively. Moreover, abnormal AST and ALT levels had a sensitivity of 91.3% and 87.0%, specificity of 88% and 85.0%, and AUC of 0.95 (95% CI 0.88-1.00) and 0.928 (95% CI 0.84-1.00). The logistic regression results showed that the odds ratio for ALT>45 IU/L was 8.18 (95% CI 2.20, 30.31, P=0.002).

**Conclusion:** Serum ALT, AST, amylase, and lipase levels may be valuable in predicting BAT in children. However, further studies with more patients are necessary to confirm the results of the present study.

**Keywords:** Abdominal injuries, Computed Tomography, Amylase, Lipase, Child.

## Introduction

Blunt abdominal trauma (BAT) is one of the most common causes of mortality and morbidity in all age categories. Diagnosing and treating patients with BAT is still challenging. Many injuries cannot be distinguished in the initial evaluations, and the initial assessments of these patients are usually difficult and inaccurate.<sup>[1,2]</sup>

Several diagnostic methods are performed for the initial consideration of BAT. Evaluation or management seems to be more appropriate than consideration. In this regard, the role of non-invasive tests, including computed tomography (CT), ultrasonography, and focused abdominal sonography for trauma (FAST) scans, is well recognized.<sup>[3,4]</sup> Indeed, CT is considered the gold standard

for evaluating intra-abdominal injuries. Although it has known advantages, CT propagates the risk of malignancies due to radiation exposure. Additionally, children are more sensitive to ionizing radiation than adults and have a higher risk of malignancies over time.<sup>[5,6]</sup> Therefore, investigating alternative non-invasive and safe methods for assessing BAT, especially in children, is beneficial.

Contextually, laboratory tests may be a promising and safe candidate for the initial diagnosis of children with BAT. However, the diagnostic value of different laboratory tests for BAT is still controversial. Many studies have emphasized the efficiency of laboratory tests, including amylase and lipase, in managing BAT. In contrast, some studies supported that they have no diagnostic value.<sup>[7-9]</sup>

## Objectives

Hence, in this study, we aimed to investigate the relationship between intra-abdominal injuries and clinical, imaging, and laboratory findings in children with BAT.

## Methods

### Study Population

This cross-sectional study evaluated all children under 18 years old with minor BAT referred to the level-1 trauma center of Hashminejad, Taleghani, and Emdadi Hospitals Affiliated with Mashhad University of Medical Sciences between September 2018 and June 2019. Children who were candidates for CT of the abdomen and pelvis for evaluating solid organ injury were included in the present study. The exclusion criteria were patients with reduced consciousness (GCS<15) whose abdominal examination was unreliable, those with a history of hypersensitivity to contrast, or a simultaneous hip fracture.

### Evaluation of outcome

The demographic information (age, gender, triage level), the mechanism of injury (low- or high-energy), and the physical examination were recorded. In addition, vital signs at the time of the visit, including systolic blood pressure (SBP), diastolic blood pressure (DBP), pulse rate (PR), and respiratory rate (RR), were measured. Furthermore, we evaluated laboratory tests, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), amylase, lipase, CBC, and urine analysis (UA). In addition, hemoglobin was measured at the first visit (Hemoglobin 1) and after 24 h (Hemoglobin 2). All patients also underwent FAST and CT, and data were recorded.

According to the commercial kits, elevated liver enzymes were defined as abnormal if either serum AST or ALT levels were  $\geq 40$  IU/L. Elevated amylase and lipase enzymes were defined as abnormal if they were  $\geq 140$  and  $160$  IU/L, respectively. Furthermore, abnormal hemoglobin levels were considered  $\leq 11$  g/dl. Hematuria was also diagnosed, with RBCs  $> 50$  seen on urine analysis.<sup>[10]</sup>

Additionally, the level of consciousness was measured using the Glasgow Coma Scale (GCS), and a GCS  $< 15$  was considered an abnormal consciousness level. An abnormal physical examination was detected by abdominal tenderness.

### Statistical Analysis

All data were analyzed using the R Statistical Software (v4.1.2; R Core Team 2021) and IBM SPSS Statistics (Version 27). The normality of data was assessed using the Kolmogorov–Smirnov test. Continuous data were expressed as mean  $\pm$  SD for normal distribution and median (Quarter 1, Quarter 3) for abnormal distribution. Categorical data were shown as frequency (%). P-value  $< 0.05$  was regarded as statistically significant in all analyses.

We used the t-test or the Mann–Whitney U test for normally or abnormally distributed continuous variables, respectively. In addition, the chi-square test was implemented to investigate the association between the categorical variables. Finally, the variance inflation factor (VIF) and the correlation coefficient computation were used to assess the multicollinearity between independent variables. Generally, a correlation higher than 0.7 was considered a highly correlated variable that helped to recognize the possibility of multicollinearity.

We assessed the association between laboratory findings and the incident FAST exam, Physical Examination, and CT in the adjusted and crude logistic regression. To compare models and study the model's goodness of fit, the Akaike information criterion (AIC) was used. Lower AIC values indicated the model fits better with less error. The areas under the curve (AUC) of the ROC curve with 95% confidence intervals (CIs), sensitivity, specificity, precision, and accuracy were assessed and compared with the FAST exam, physical examination, and CT in the adjusted logistic regression.

### Ethical considerations

This study was approved by the ethics committee of Mashhad University of Medical Sciences (approval code: IR.MUMS.MEDICAL.REC.1399.034). In addition, we obtained written informed consent from the child's parents or legal guardian before their inclusion in the study.

**Results**

**Demographic, clinical, and laboratory characteristics of the study population**

We evaluated 96 children with BAT with a median age of 10.5 (Q1, 8, Q3, 13), and about 72% were male. The triage level for 9.1% of patients was 1, 76% was 2, 15.2% was 3 or 4, and 90% had a normal GCS score. The median SBP and DBP were 100 (Q1, 94, Q3, 110) and 70 (Q1, 60, Q3, 98.1), respectively. Moreover, 23% of patients had abnormal amylase levels, and 12% had abnormal lipase levels. Abnormal ALT and AST levels were reported in 31% and 34%, respectively [Table-1].

**Table-1.** Demographic and clinical characteristics of children with blunt abdominal trauma

Characteristic	Category / Value	Median (Q1, Q3) or N (%)	P-value <sup>a</sup>
Age (years)	—	10.5 (8, 13)	—
	1–6	18 (18)	<0.001
	6–11	35 (36)	
	>11	43 (44)	
Gender	Male	69 (72)	<0.001
	Female	27 (28)	
Triage level	1	9 (9.10)	<0.001
	2	75 (75.8)	
	3–4	15 (15.2)	
Damage mechanism	Low energy	18 (18.2)	<0.001
	High energy	81 (81.2)	
GCS	Normal	89 (89.9)	<0.001
	Abnormal	10 (10.10)	
Seven-day prognosis	Discharge	40 (40.4)	0.056
	Hospitalized	59 (59.6)	
CT findings	Kidney damage	5 (5.2)	—
	Hepatic damage	10 (10.4)	
	Splenic damage	7 (7.2)	
	Normal	74 (77.2)	
FAST	Normal	77 (80.2)	—
	Abnormal	19 (19.8)	
Physical examination	Normal	44 (45.8)	—
	Abnormal	52 (54.2)	
SBP (mmHg)	Median (Q1, Q3)	100 (94, 110)	0.61
	Normal	52 (52.5)	
	Abnormal	47 (47.5)	
DBP (mmHg)	Median (Q1, Q3)	70 (60, 98.1)	<0.001
	Normal	55 (55.6)	
Abnormal	44 (44.4)		
	Median (Q1, Q3)	57 (48, 136)	<0.001
Amylase (IU/L)	Normal	76 (76.8)	
	Abnormal	23 (23.2)	
	Median (Q1, Q3)	28 (23, 105.25)	<0.001
Lipase (IU/L)	Normal	87 (87.5)	
	Abnormal	12 (12.1)	
AST (IU/L)	Median (Q1, Q3)	32 (24.25, 44.75)	0.002
	Normal	65 (65.7)	
	Abnormal	34 (34.3)	
ALT (IU/L)	Median (Q1, Q3)	31 (23.25, 45.75)	<0.001
	Normal	68 (68.7)	
	Abnormal	31 (31.3)	
Hematuria	Yes	16 (16.2)	<0.001
	No	83 (83.8)	
Hemoglobin 1 (g/dL)	Mean ± SD	12.47 ± 1.38	<0.001
	Normal	87 (87.9)	
	Abnormal	12 (12.1)	
Hemoglobin 2 (g/dL)	Mean ± SD	12.11 ± 1.39	<0.001
	Normal	78 (79.6)	
	Abnormal	20 (20.4)	

PR (beats/min)	Normal	30 (30.3)	
	Abnormal	69 (69.7)	
RR (breaths/min)	Median (Q1, Q3)	100 (88.25, 110)	0.54
	Normal	52 (53.1)	
Abnormal	46 (46.9)		
	Median (Q1, Q3)	20 (19, 22)	0.26
Normal	55 (55.6)		
	Abnormal	44 (44.4)	
Amylase (IU/L)	Median (Q1, Q3)	57 (48, 136)	<0.001
	Normal	76 (76.8)	
	Abnormal	23 (23.2)	
Lipase (IU/L)	Median (Q1, Q3)	28 (23, 105.25)	<0.001
	Normal	87 (87.5)	
	Abnormal	12 (12.1)	
AST (IU/L)	Median (Q1, Q3)	32 (24.25, 44.75)	0.002
	Normal	65 (65.7)	
	Abnormal	34 (34.3)	
ALT (IU/L)	Median (Q1, Q3)	31 (23.25, 45.75)	<0.001
	Normal	68 (68.7)	
	Abnormal	31 (31.3)	
Hematuria	Yes	16 (16.2)	<0.001
	No	83 (83.8)	
Hemoglobin 1 (g/dL)	Mean ± SD	12.47 ± 1.38	<0.001
	Normal	87 (87.9)	
	Abnormal	12 (12.1)	
Hemoglobin 2 (g/dL)	Mean ± SD	12.11 ± 1.39	<0.001
	Normal	78 (79.6)	
	Abnormal	20 (20.4)	

Glasgow Coma Scale: GCS, Computed tomography: CT, Focused Abdominal Sonography for Trauma: FAST, SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, RR: respiratory rate, ALT: alanine aminotransferase, AST: aspartate aminotransferase; <sup>a</sup> Compared using the Chi-square test.

**The results of demographic, clinical, and laboratory tests according to the FAST exam condition**

Our findings revealed that the FAST exam results were normal in 77 patients and abnormal in 19 patients among 96 eligible participants. The median of amylase, lipase, ALT, and AST tests was significantly higher in patients with abnormal FAST exam results than in those with normal results (P<0.001). Furthermore, we observed a significant difference in age categories between patients with normal and abnormal FAST exams (P=0.036) [Table-2].

**Table-2.** Description of characteristics of study participants according to the results of the FAST exam

Variable	Total (n = 96)	FAST Exam		P-value
		Normal (n = 77)	Abnormal (n = 19)	
SBP (mmHg)	100 (94, 110)	100 (94, 110)	108 (100, 110)	0.233
DBP (mmHg)	70 (60, 98.1)	70 (60, 74)	70 (60, 75)	0.496
PR (beats per minute)	100 (88.25, 110)	100 (88, 110)	100 (92, 110)	0.797
RR (breaths per minute)	20 (19, 22)	20 (18.5, 22)	21 (20, 23)	0.458
Amylase (IU/L)	57 (48, 136)	51 (49, 78)	165 (141, 194)	0.000
Age (Years)	10 (8, 13)	10 (7, 13)	12 (9, 13)	0.141
Lipase (IU/L)	28 (23, 105.25)	25 (21, 55)	161 (109, 197)	0.000
Hemoglobin 1 (g/dL)	12.47±1.38	12.57±1.26	12.08±1.78	0.283
Hemoglobin 2 (g/dL)	12.11±1.39	12.20±1.40	11.75±1.35	0.211
Gender				0.427
Male	69 (72)	54 (70)	15 (78)	
Female	27 (28)	23 (29)	4 (21)	
Seven-day prognosis	38 (40)	32 (42)	6 (31)	0.401
Discharge	57 (60)	44 (57)	13 (68)	
Age				0.036
1-6	18 (18)	16 (20)	2 (10)	
6-11	35 (36)	31 (40)	4 (21)	
>12	43 (44)	30 (38)	13 (68)	
AST (IU/L)	32 (24.25, 44.75)	30 (24, 40.5)	90 (40, 209)	0.000
ALT (IU/L)	31 (23.25, 45.75)	28 (23, 38.5)	79 (40, 240)	0.000
ALT				0.000
< 24	29 (30)	27 (35)	2 (10)	
24 - 31	21 (21)	19 (24)	2 (10)	
31 - 45	22 (25)	19 (24)	3 (15)	
> 45	24 (25)	12 (15)	12 (63)	

SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, RR: respiratory rate, ALT: alanine aminotransferase, AST: aspartate aminotransferase; Data were presented as median (Q<sub>1</sub>, Q<sub>3</sub>) or Mean ± SD for continuous variables, and N (%) for categorical variables; <sup>a</sup> compared using T-Test or Mann-Whitney U test, or Chi-square tests.

### The results of demographic, clinical, and laboratory tests according to the CT findings

Among 96 eligible participants, 74 had normal CT results, and 22 had abnormal CT results. We found that the median of amylase, lipase, AST, and ALT was higher in patients with abnormal CT results than in those with

normal CT results ( $P < 0.001$  for all). However, the level of second hemoglobin ( $P = 0.032$ ) was lower in patients with abnormal CT than in those with normal CT results. In addition, among patients with abnormal and normal CT, 13% and 48% were discharged, and 86% and 52% were hospitalized, respectively ( $P = 0.001$ ) [Table-3].

**Table 3.** Description of characteristics of study participants according to the results of CT

Variable	Total (n = 96)	CT		P-value
		Normal (n = 74)	Abnormal (n = 22)	
SBP (mmHg)	100 (94,110)	100 (93.5, 110)	103.5 (94.75, 11.75)	0.334
DBP (mmHg)	70 (60, 98.1)	70 (60,75)	69.5 (59.5,73.75)	0.278
PR (beats per minute)	100 (88.25, 110)	100 (88, 110)	100 (90.75, 108.5)	0.988
RR (breaths per minute)	20 (19,22)	20 (19, 22)	20.5 (19.5, 22)	0.757
Amylase (IU/L)	57 (48, 136)	50 (46, 63)	164.5 (152.25,190.25)	0.000
Lipase (IU/L)	28 (23, 105.25)	25 (21,37.25)	165 (134.75,191.75)	0.000
Hemoglobin 1 (g/dL)	12.11±1.39	12.29±1.33	11.5±1.47	0.032
Hemoglobin 2 (g/dL)	12.62±1.18	12.62±1.18	11.97±1.86	0.211
Gender				0.677

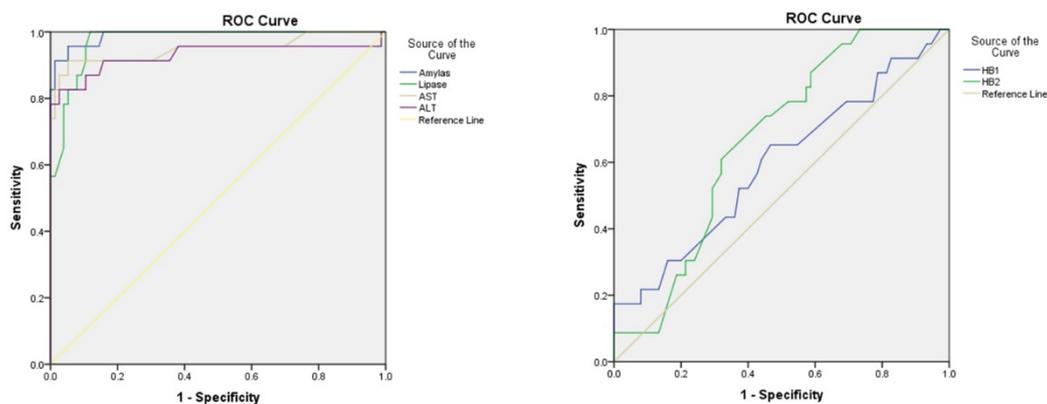
<b>Male</b>	69 (72)	54 (72)	15 (68)	
<b>Female</b>	27 (28)	20 (27)	7 (31)	
<b>Seven-day prognosis</b>	38 (40)	35 (48)	3 (13)	0.001
<b>Discharge</b>	57 (60)	38 (52)	19 (86)	
<b>Age (Years)</b>	10 (8,13)	10 (7,13)	12(8,13.25)	0.261
<b>Age</b>				0.172
<b>1-6</b>	18 (18)	15 (20)	3 (13)	
<b>6-11</b>	35 (36)	29 (39)	6 (27)	
<b>&gt;12</b>	43 (44)	30 (40)	13 (59)	
<b>AST (IU/L)</b>	32(24.25, 44.75)	29 (23.75, 38)	100 (57.25, 224)	0.000
<b>ALT (IU/L)</b>	31 (23.25, 45.75)	26 (23, 37.25)	93 (57.25, 290)	0.000
<b>ALT</b>				0.000
<b>&lt; 24</b>	29 (30)	28 (37)	1 (4)	
<b>24 - 31</b>	21 (21)	20 (27)	1 (4)	
<b>31 - 45</b>	22 (23)	20 (27)	2 (9)	
<b>&gt; 45</b>	24 (25)	6 (8)	18 (81)	

CT: computed tomography, SBP: systolic blood pressure, DBP: diastolic blood pressure, PR: pulse rate, RR: respiratory rate, ALT: alanine aminotransferase, AST: aspartate aminotransferase; Data were presented as median (Q<sub>1</sub>, Q<sub>3</sub>) or Mean ± SD for continuous variables, and N (%) for categorical variables; <sup>a</sup> compared using T-Test or Mann–Whitney U test, or Chi-square tests.

### The sensitivity and specificity of laboratory markers compared to the standard CT test

The abnormal amylase showed 91.3% sensitivity, 97% specificity, and an area under the ROC curve of 0.99 (95% CI 0.975-1.00). Furthermore, abnormal lipase showed 52%

sensitivity, 100% specificity, and an area under the ROC curve of 0.973 (95% CI 0.947-0.99). Moreover, abnormal AST and ALT levels had a sensitivity of 91.3% and 87.0%, specificity of 88% and 85.0%, and area under the ROC curve of 0.95 (95% CI 0.88-1.00) and 0.928 (95% CI 0.84-1.00), respectively [Figure-1].



Characteristics	Sensitivity, %	Specificity, %	AUC	95% CI	P-value
Abnormal Amylase	91.3	97	0.99	0.975-1.00	<0.001
Abnormal Lipase	52	100	0.973	0.947-0.99	<0.001
Abnormal AST	91.3	88	0.95	0.88-1.00	<0.001
Abnormal ALT	87	85	0.928	0.84-1.00	<0.001
Abnormal Hemoglobin 2	26	82	0.66	0.55-0.77	0.016
Abnormal Hemoglobin 1	22	90	0.6	0.45-0.73	0.172

**Figure-1.** The ROC curve for evaluation of sensitivity and specificity of clinical laboratory markers compared to the standard CT; CT: computed tomography, ALT: alanine aminotransferase, AST: aspartate aminotransferase, AUC: area under the curve, CI: confidential interval.

**Table-4.** Association of children with blunt abdominal trauma indices with the incidence of A) physical examination, B) FAST exam, and C) CT for a one standard deviation increase

<b>A) Physical examination</b>				
<b>Variable</b>	<b>Crude OR (95% CI)</b>	<b>P-value</b>	<b>Adjusted OR (95% CI)</b>	<b>P-value</b>
<b>Lipase</b>	1.01 (1.01, 1.02)	0.002	1.01 (1.00, 1.02)	0.014
<b>Hemoglobin 2</b>	1.36 (0.99, 1.86)	0.056	1.97 (1.31, 2.98)	0.001
<b>ALT (IU/L)</b>				
(< 24)	Ref	-	Ref	-
(24 – 31)	1.01 (0.32, 3.20)	0.991	1.08 (0.28, 4.13)	0.905
(31 – 45)	2.36 (0.76, 7.34)	0.137	2.42 (0.63, 9.40)	0.200
(> 45)	8.18 (2.20, 30.31)	0.002	7.06 (1.23, 40.37)	0.028
<b>Age (Years)</b>				
(< 6)	Ref	-	Ref	-
(6 – 11)	3.043 (0.86, 10.75)	0.084	6.588 (1.36, 31.86)	0.019
(> 11)	0.652 (0.26, 1.60)	0.351	1.063 (0.34, 3.32)	0.917
<b>Adjusted</b>	Sensitivity =0.74 AIC = 111.43	AUC= 0.83 precision = 0.76	Specificity = 0.80 Accuracy = 0.78	
<b>B) FAST exam</b>				
<b>Variable</b>	<b>Crude OR (95% CI)</b>	<b>P-value</b>	<b>Adjusted OR (95% CI)</b>	<b>P-value</b>
<b>AST</b>	1.01 (1.01, 1.02)	0.000	1.00 (0.99, 1.02)	0.197
<b>Hematuria</b>	1.01 (1.00, 1.02)	0.055	1.02 (1.00, 1.03)	0.024
<b>ALT (IU/L)</b>				
(< 24)	Ref	-	Ref	-
(24 – 31)	1.42 (0.18, 10.99)	0.736	1.49 (0.18, 12.38)	0.710
(31 – 45)	2.13 (0.32, 14.01)	0.431	1.39 (0.18, 10.88)	0.748
(> 45)	13.50 (2.60, 69.88)	0.002	7.40 (0.84, 64.68)	0.070
<b>Age (Years)</b>				
(< 6)	Ref	-	Ref	-
(6 – 11)	1.03 (0.17, 6.25)	0.972	1.024 (0.13, 7.64)	0.981
(> 11)	3.46 (0.69, 17.30)	0.130	4.16 (0.66, 26.15)	0.127
<b>Adjusted</b>	Sensitivity =0.94 AIC = 84.72	AUC= 0.82 precision = 0.87	Specificity = 0.42 Accuracy = 0.84	
<b>C) CT</b>				
<b>Variable</b>	<b>Crude OR (95% CI)</b>	<b>P-value</b>	<b>Adjusted OR (95% CI)</b>	<b>P-value</b>
<b>Hematuria</b>	1.01 (1.01, 1.02)	0.002	1.03 (1.00, 1.06)	0.007
<b>AST</b>	1.36 (0.99, 1.86)	0.056	1.02 (0.99, 1.03)	0.071
<b>ALT (IU/L)</b>				
(< 24)	Ref	-	Ref	-
(24 – 31)	1.01 (0.32, 3.20)	0.991	1.92 (0.09, 38.51)	0.670
(31 – 45)	2.36 (0.76, 7.34)	0.137	2.17 (0.12, 39.99)	0.603
(> 45)	8.18 (2.20, 30.31)	0.002	81.88 (3.35, 2002.5)	0.007
<b>Age (Years)</b>				
(< 6)	Ref	-	Ref	-
(6 – 11)	3.043 (0.86, 10.75)	0.084	1.305 (0.12, 14.23)	0.827
(> 11)	0.652 (0.26, 1.60)	0.351	3.79 (0.37, 38.43)	0.258
<b>Adjusted</b>	Sensitivity =0.97 AIC = 57.63	AUC= 0.96 precision = 0.93	Specificity = 0.77 Accuracy = 0.93	

CT:computed tomography, ALT:alanine aminotransferase, AST:aspartate aminotransferase, AUC: area under the curve, CI: confidential interval, OR: odds ratio.

### The results of the logistic regression in children with blunt abdominal trauma

The crude regression of physical examination showed that the second hemoglobin had an odds ratio (OR) of 1.36 (95% CI 0.99, 1.86;  $P=0.001$ ). In addition, the odds ratio for ALT > 45 IU/L was 8.18 (95% CI 2.20, 30.31,  $P=0.002$ ). Other variable indices were excluded because of multicollinearity. The adjusted logistic regression yielded results very similar to those of the crude logistic regression. In contrast, only ages 6-11 years had an OR of 6.588 (95% CI 1.36, 31.86,  $P = 0.019$ ) [Table 4a].

The results of crude regression of the FAST exam showed that the OR for ALT > 45 IU/L was 13.5 (95% CI 2.60, 69.88,  $P=0.002$ ). Other variable indices were excluded because of multicollinearity. The adjusted logistic regression result was very similar to the crude logistic regression result. While AST and ALT > 45 IU/L were insignificant ( $P=0.197$  and  $0.07$ , respectively) [Table 4b].

The results of crude regression of CT showed that the odds ratio for ALT > 45 IU/L was 8.18 (95% CI 2.20, 30.31,  $P=0.002$ ). However, for the variable of "age", the odds ratio decreased from 3.04 to 0.65, which was insignificant. The adjusted logistic regression result was very similar to the crude logistic regression result [Table 4c].

### Discussion

A total of 96 children with BAT were evaluated in this study. Organ injury was observed in 33% of patients on CT, 20% on FAST, and 54% on physical examination. The abnormal levels of amylase and lipase showed 91.3% and 52% sensitivity, 97% and 100% specificity. Moreover, abnormal AST and ALT levels had a sensitivity of 91.3% and 87.0%, and a specificity of 88% and 85.0%. BAT is one of the most common causes of mortality and morbidity in all age categories, especially children.<sup>[11]</sup> The organs mostly injured due to BAT consist of the kidney, liver, gastrointestinal tract, and spleen. In addition, early diagnosis of BAT and organ injury is critical for appropriate and successful treatment.<sup>[12, 13]</sup>

CT is considered the gold standard for evaluating intra-abdominal injuries. Despite its advantages, CT propagates the risk of malignancies due to radiation exposure. Therefore, investigating alternative non-invasive and safe methods for assessing BAT, especially in children, is beneficial.<sup>[14, 15]</sup> In this regard, this study aimed to evaluate the association between intra-abdominal injuries and clinical, imaging, and laboratory findings in children with BAT.

The present study evaluated 96 children with BAT with a

median age of 10.5 (8, 13), and about 72% were male. Solid organ injury was observed in 33% of patients on CT, 20% on FAST, and 54% on physical examination. In line with our results, previous studies supported that a positive FAST result most probably indicates BAT. However, a normal FAST result needs further evaluations, especially CT in order to diagnose blunt abdominal injury precisely.<sup>[16, 17]</sup> Similarly, Calder *et al.* diagnosed organ injury in 14% of patients using FAST and 10% using CT. They also observed a low correlation ( $r = -0.050$ ,  $p < 0.001$ ) between FAST and CT, and a low sensitivity for FAST (28%) in order to detect BAT in children.<sup>[18]</sup> Collectively, the FAST exam could not be a reliable method for detecting blunt abdominal injury instead of CT.

Several pieces of evidence suggested that laboratory tests, such as amylase, lipase, ALT, and AST, are indicators for diagnosing blunt abdominal injury and solid organ injury. In the present study, the levels of amylase, lipase, AST, and ALT were higher, while the second hemoglobin was lower in children with abnormal CT results than in those with normal CT results. Similarly, Streck *et al.*, showed that the frequencies of abnormal AST, amylase, and hematocrit levels were significantly higher in children with abnormal CT than in those with normal CT results.<sup>[8]</sup> Another study also showed that serum amylase, ALT, AST, hemoglobin, and hematocrit levels were significant in children with abdominal organ injuries.<sup>[19]</sup> Singh and coworkers suggested that serum amylase and lipase levels increased markedly in patients aged 25 to 45 years with solid organ injury.<sup>[20]</sup> These studies may confirm our results regarding the increment of amylase, lipase, AST, and ALT in patients with BAT confirmed by CT.

Additionally, the abnormal amylase, AST, and ALT levels showed excellent predictive ability for detecting BAT in children compared to the gold standard CT. The results of crude regression showed that the odds ratio for ALT > 45 IU/L was 8.18 (95% CI 2.20, 30.31,  $P=0.002$ ). In line with our results, Hynick and coworkers noticed that hematuria and elevated serum ALT are significant predictors (OR= 3.1; 95% CI 1.5, 6.4 and OR=5.5; 95% CI 1.7, 18.0, respectively) of BAT in children.<sup>[21]</sup> Similarly, the odds ratio of abnormal AST levels for predicting abdominal injury in children was 46.75 (95% CI 10.9, 200.7,  $P<0.01$ ).<sup>[8]</sup> Another study also suggested that the odds ratios were 15.3 (95% CI 5.8, 43.8) and 18.6 (95% CI 7.5, 49.8) for abnormal AST and ALT levels, respectively.<sup>[9]</sup> Mosaddegh and coworkers also emphasized that a combination of abdominal ultrasound and elevated levels of amylase, ALT, and AST may be a valuable alternative to CT for diagnosing blunt abdominal injuries.<sup>[22]</sup> Taken together,

these studies are consistent with our results regarding the valuable role of abnormal amylase, ALT, and AST levels as an alternative to CT for diagnosing blunt abdominal injury. Noteworthy, laboratory data can be an adjunct to FAST and CT-scan, but cannot completely replace them.

Hosseinejad et al., supported that amylase and lipase levels strongly predict pancreatic damage in patients with BAT.<sup>[23]</sup> Previous studies also showed that abnormal lipase and amylase levels are beneficial for detecting pancreatic injury.<sup>[24]</sup> However, we had no children with pancreatic injury among our studied patients, which may be the reason for the moderate predictive ability of lipase (52% sensitivity and 100% specificity) for identifying the blunt abdominal injury.

The sensitivity and specificity of imaging modalities (e.g., ultrasound) can vary, potentially leading to false-negative or false-positive diagnoses of intra-abdominal injuries. In this study, the researchers focused on identifying free fluid using the FAST examination with a specific ultrasound device. Additionally, a notable limitation of this study was the absence of CT scans for certain patients. This occurred for various reasons, including instances in which patients were discharged from the hospital before completing their treatment at the request of their families, as well as cases in which patients or their guardians declined to permit a CT scan.

## Conclusions

It could be concluded that serum ALT, AST, amylase, and lipase levels may be valuable in predicting BAT in children and may be considered a reliable alternative to CT. However, further studies with more patients are necessary to confirm our results.

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## Competing interests

The authors declare that they have no competing interests.

## Abbreviations

Alanine aminotransferase: ALT; Areas under the curve: AUC; Aspartate aminotransferase: AST; Computed Tomography: CT; Confidence intervals: CIs; Diastolic blood pressure: DBP; Focused abdominal sonography for trauma: FAST; Focused Abdominal Sonography for Trauma: FAST; Glasgow coma scale: GCS; Pulse rate: PR; Respiratory rate: RR; Systolic blood pressure: SBP; Urine analysis: UA; Variance inflation factor: VIF.

## Authors' contributions

SMM: Conceptualisation, Methodology, Supervision, Funding Acquisition; EFM: Conceptualisation, Methodology, Supervision, Investigation; VRA: Formal Analysis, Software, Data Curation, Writing – Original Draft; SGH: Formal Analysis, Software, Data Curation, Writing – Original Draft; BA: Investigation, Data Curation; VBR: Formal Analysis, Writing – Original Draft, Writing – review & editing. All authors read and approved the final manuscript. All authors take responsibility for the integrity of the data and the accuracy of the data analysis.

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None.

## Availability of data and materials

The data used in this study are available from the corresponding author on request.

## Ethics approval and consent to participate

This study was approved by the ethics committee of Mashhad University of Medical Sciences (approval code: IR.MUMS.MEDICAL.REC.1399.034). In addition, we obtained written informed consent from the child's parents or legal guardian before their inclusion in the study.

## Consent for publication

By submitting this document, the authors declare their consent for the final accepted version of the manuscript to be considered for publication.

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