http:// ijp.mums.ac.ir
Original Article (Pages: 8047-8059)

# The Utility of Ultrasound and Laboratory Data for Predicting Intra-abdominal Injury among Children with Blunt Abdominal Trauma

Ayoub Ashrafi[1], *Farhad Heydari[2], Mohsen Kolahdouzan[3]

[1]Emergency Medicine Specialist, Alzahra Hospital, Emergency Medicine Specialist, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
[2]Emergency Medicine Research Center, Alzahra Hospital, Department of Emergency Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.
[3]Associate Professor, Alzahra Hospital, General Surgery Specialist, Thoracic Surgery Subspecialist, Associate Professor of Isfahan University of Medical Sciences, Isfahan, Iran.

***Abstract***

***Background:*** Children with blunt abdominal trauma (BAT) can be risk stratified for intra-abdominal injury (IAI) through a combination of readily accessible clinical variables. The aim of this study was to identify ultrasound and laboratory studies that accurately identify IAI while limiting unnecessary CT-scan among children without injury.

***Materials and Methods***

We conducted a prospective, observational study of 2-12 years old children with BAT who referred to the emergency department (ED) at Al-zahra and Kashani hospitals in Isfahan city, Iran, from January 2013 to May 2014**.** Children were undergone abdominal ultrasound and abdominal CT scan was done at the discretion of the treating physicians and according to the CT protocols. The tests obtained to assess for an IAI were including hematocrit (HCT), amylase, aspartate aminotransferase (AST) or alanine aminotransferase (ALT) and urinalysis (U/A). The outcome were any IAI and intra-abdominal injury undergoing acute intervention (IAI-I).

***Results:*** We enrolled 101 children with a median age of 6.75 ± 3.2 years. There were 18 (17.8%) patients with IAI, and 5(5%) patients with IAI-I. The sensitivity, specificity and positive predictive value and negative predictive value of ultrasound compared to CT- scan were 72.2%, 85.5%, 52%, and 93.3%, respectively. It is notable that all 18 patients with IAI (Se=100%) had at least one positive test. The combination of ultrasound, ALT/AST, HCT, urinalysis and amylase tests (with at least one positive test) has negative predictive values of 100%.

***Conclusion:*** It can be argued that ultrasound combined with selected laboratory studies can be used to predict the risk of IAI accurately among children who sustain BAT. According to the results of this study, we can say that ultrasound and laboratory studies should be obtained as a screening tool in these cases.

***Key Words:*** Blunt abdominal trauma, Emergency department, Pediatric, Ultrasound.

*Please cite this article as: Ashrafi A, Heydari F, Kolahdouzan M. The Utility of Ultrasound and Laboratory Data for Predicting Intra-abdominal Injury among Children with Blunt Abdominal Trauma. Int J Pediatr 2018; 6(8): 047-59. DOI: **10.22038/ijp.2018.29824.2626**

***Corresponding Author:***

Farhad Heydari, Emergency Medicine Research Center, Alzahra Hospital, Department of Emergency Medicine, Isfahan University of Medical Sciences, Isfahan, Iran.

Email: drmsrezaii@yahoo.com

Received date: Feb.05, 2018; Accepted date: Mar. 22, 2018

## 1- INTRODUCTION

The life of critically ill or injured children depends on the speed and accuracy of emergency cares. These cares start with rapid diagnosis of serious diseases and continue in all conditions before and after hospitalization. Despite profound advances in reduction of adults' mortality in emergencies, due to difficult diagnosis of life-threatening disorders in kids, this index has not significantly decreased in kids (1, 2). Intra-abdominal injury (IAI) is a leading cause of morbidity in children (3), and early identification is imperative to minimize morbidity and mortality from delayed or missed diagnosis. The most important mortality cause in 2-12 years old kids is accidents which half of it consists of accidents with motor vehicles. The next main cause of death in kids includes falling (25 - 30%) (3-6). More than half of death incident due to trauma happens in the place of accident. While if patient reaches care center and has a constant condition for one hour after injury, he/ she will have a good fate (3, 4).

Blunt abdominal trauma (BAT) is very common in children. The most susceptible parts that suffer are spleen, liver, genitourinary tract, stomach, small intestine, colon, pancreas, pelvis and large vessels, respectively (7, 8). Optimal treatment of affected kids with stable condition requires frequent physical examination and performing CT-scan to prove the presence and extent of injury. In case of unstable vital signs in addition to severe fluid resuscitation, even if the extravascular volume has not decreased or the abdomen has not enlarged the patient might require surgery. If there are signs of peritoneal irritation or discoloration of abdominal wall along with signs of intravascular volume depletion, laparotomy is necessary. In the studies, CT-Scan is proposed as the standard diagnostic instrument; however, CT-scan equipments are not available in all medical centers and areas. It has important drawbacks, primarily that it exposes patients to relatively large radiation dosages, placing them at increased risk of radiation-induced malignancy (9).Thus, it is required to try to achieve some instrument which can specify the status of patient reliably with high accuracy. In this regard, the studies which have been done indicated the great role of ultrasound in rapid and immediate diagnosis of some injuries (10-13). Several studies suggest that children with BAT can be risk stratified for IAI through a combination of readily accessible clinical variables (14-17). Thus, concerning the above-mentioned findings and the fact that ultrasound is less aggressive than CT-scan and more available, in case of efficiency, this instrument can replace CT-scan. The present study aimed to identify ultrasound and laboratory studies that accurately identify IAI while limiting unnecessary CT-scan among children without injury. Variables (ultrasound and laboratory studies) available at the time of initial ED evaluation were considered as potential predictors.

## 2- MATERIALS AND METHODS

### 2-1. Study Design

We conducted a prospective, observational study of children with BAT that was referred to the ED. The study was approved by the by the Ethics Committee of Isfahan University of Medical Sciences (IR.mui.RES.1392.3.292). This study was conducted at Al-zahra and Kashani hospitals in Isfahan city, Iran, from January 2014 to May 2015.

### 2-2. Selection of Participants

Children with BAT evaluated in the ED at Al-zahra and Kashani hospitals in Isfahan, Iran from January 2013 to May 2014 were eligible. Inclusion criteria were children 2-12 years of age presenting with BAT due to predefined high-risk mechanism of

injury. We chose to include children with high-risk mechanisms of injury because of several authors have suggested would be most likely to benefit from CT-scan (18-20). High-risk mechanisms of injury were chosen based on review of existing literature (18-22) (**Table.1**).

**Table-1**: High-risk mechanisms

| |
|---|
| High-speed motor vehicle collision (≥40mph or 64 kph ) |
| Ejection from vehicle |
| Death of another passenger in same vehicle compartment |
| Falls from >10 feet (3 m) or more than 2 to 3 times patient height or >5 stairs |
| Roll-over of vehicle |
| Vehicle-pedestrian/bicycle collision with >5 mph (8 kph) impact |
| Motorcycle crash >20 mph (32 kph) or with separation of rider from bike |

(Reference: American College of Surgeons, Committee on Trauma: Resources for the optimal care of the injured patient, Chicago, 2012). Mph: miles per hour; kph: kilometers per hour.

Patients were excluded if they met any of the following criteria: abnormal pediatric age-adjusted shock index (heart rate/systolic blood pressure), Glasgow coma scale <15, sustained penetrating trauma, abnormality in Chest X-ray (CXR), presenting >12 h after trauma or transferred from another hospital.

## 2-3. Study Protocol

The sampling method was census and all children having inclusion criteria referred to these centers in the mentioned time interval were included in this study. The minimum required sample was estimated through estimation formula of sample volume for prevalence studies, reliability of 95% confidence interval, and ultrasound sensitivity of 0.8 and error acceptance rate of 0.1 as 61 individuals and subjects. We recorded demographic variables (age and gender), mechanism of injury (motor vehicle collision, pedestrian struck, cyclist struck, fall down stairs, fall from height, assault), physical examination findings, laboratory values of hematocrit (HCT), amylase, aspartate aminotransferase (AST) or alanine aminotransferase (ALT), and urinalysis (U/A), ultrasound and abdominal CT findings. Observed loss of consciousness at the scene and in the hospital, the time from injury until initial evaluation and whether this evaluation was first performed at another hospital were evaluated. Recorded data collected included aspects of the physical examination included the initial vital signs (blood pressure, pulse, respiratory rate, and temperature), abdominal examination (the presence or absence of distention, abrasions, ecchymosis, seatbelt or handlebar contusion or tenderness), and Glasgow Coma Score (14).

The method of study was such that 2-12 years old kids suffering from BAT were undergone abdominal ultrasound after taking their history and physical examination. Abdominal exam was considered abnormal if physician documentation described tenderness to palpation, peritonitis, presence of distention, abrasions or seatbelt or handlebar contusion. To prevent any bias, all ultrasounds were performed by an expert radiologist and the results were recorded in special checklist. On the other hand, the abdominal and pelvic CT-scan for these kids was done by intravenous

contrast and was performed at the discretion of the treating physicians and according to the CT protocols at each institution. The radiologist who performed the ultrasound of patient was unaware of CT-scan results. We conducted follow-up at least 14 days after the first ED visit to identify any IAI that subsequently received. Patients were defined as having no IAI if no injury was detected during initial evaluation, during hospitalization, or at outpatient follow-up evaluation.

The final results obtained from ultrasound and CT-scan was recorded. The results of tests obtained to assess for an IAI were noted including: HCT, amylase, AST or ALT, and urinalysis. Laboratory abnormalities were as follows: ALT and AST > 200 U/L, HCT < 30%, amylase >100 U/L and hematuria > 5 (Red Blood Cells per High Power Field) in U/A. According to the study patients were assessed for 6 clinical variables (ultrasound, abdominal exam, AST/ALT, HCT, amylase, hematuria) potentially associated with IAI. The presence of any one of these six variables was considered predictive of IAI.

### 2-4. Outcome Measures

The primary outcome was any IAI. Intra-abdominal injury was defined as any abdominal CT-Scan or surgically apparent injury to the following structures: spleen, liver, urinary tract (from the kidney to the urinary bladder), gastrointestinal tract (including the bowel or associated mesentery from the stomach to the sigmoid colon), pancreas, gallbladder, adrenal gland, intra-abdominal vascular structure, or traumatic fascial defect (traumatic abdominal wall hernia). The secondary outcome was intra-abdominal injury undergoing acute intervention (IAI-I). Acute intervention was defined by an IAI associated with death caused by the intra-abdominal injury, therapeutic laparotomy and blood transfusion for anemia as a result of hemorrhage from the IAI.

### 2-5. Data Analysis

Sensitivity, specificity, positive and negative predictive values and accuracy of the six variables were calculated. Logistic regression models were then used to determine whether abnormal value variables were related to the presence of IAI. The data were analyzed by SPSS version 20.0 and Med Calc. The result of CT-scan and ultrasound in patients were compared with liver enzymes, amylase and urinalysis. Parametric data were expressed as means (standard deviation) and analyzed using the unpaired, two-tailed Student's t test, assuming the variance to be equal. The Mann– Whitney test was used to compare ordinal variables. Differences between groups were analyzed using Fisher's exact test. P-value less than 0.05 were statistically significant.

## 3- RESULTS

Of the 168 eligible patients, we enrolled 101 (60.1%) (**Figure.1**); the average age of these patients were 6.75±3.2 years in range of 2-12 years old. In terms of gender distribution, 69 individuals (68.3%) were male and 31 (30.7%) were female. The average age of studied girls and boys was 6.47±3.12, and 7.16±2.84 years, respectively; and according to t-test, no significant difference was observed between two genders (p= 0.37).

The mechanisms of injury for the 101 patients were as follows: motor vehicle collision in 55 (54.5%), pedestrian struck by auto in 15 (14.9%), cycle struck by auto in 6 (5.9%), fall from height in 9 (8.9%), fall from stairs in 7 (6.9%), assault in 2 (2%) and other in 6 (5.9%) (**Table.2**).

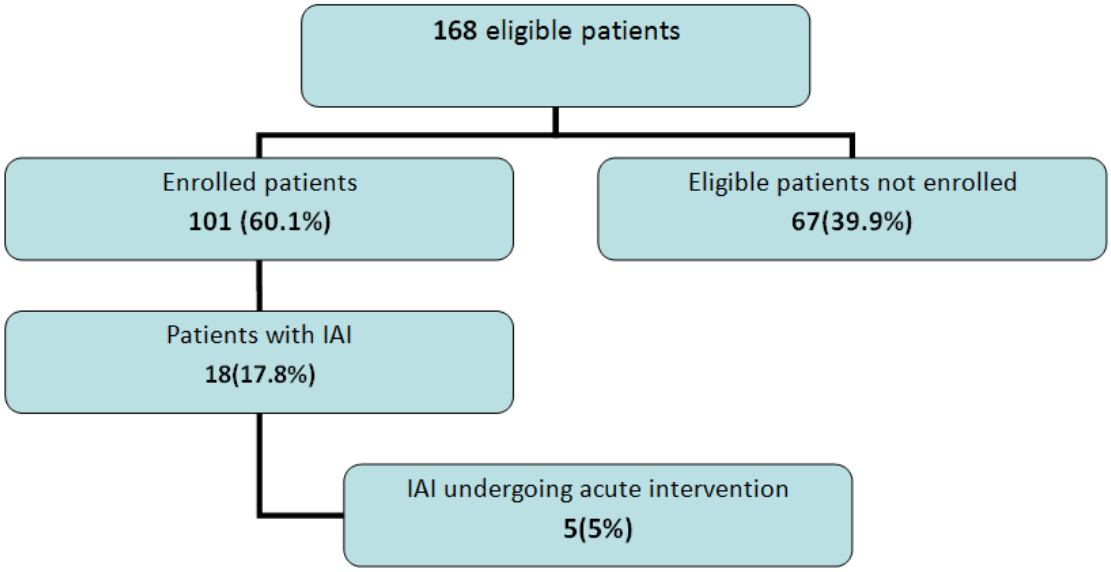


**Fig.1**: Flow Diagram of Pediatric Patients with Blunt Abdominal Trauma.

**Table-2**: Description of All Study Patients, Then Stratified by Patients with and Without Intra Abnormal Injury.

| Variables | Total, (n=101) | IAI, (n=18) | Without IAI, (n=83) |
|---|---|---|---|
| Age(Mean ± SD),year | 6.75 ± 3.2 | 6.95 ± 3.5 | 6.69 ± 2.9 |
| Gender (% male) | 69(68.3) | 13(72.2) | 56(67.5) |
| **Mechanism of injury (%)** | | | |
| Motor vehicle collision | 55(54.5) | 10(55.6) | 45(54.2) |
| Pedestrian struck | 15(14.9) | 3(16.7) | 12(14.5) |
| Cyclist struck | 6(5.9) | 1(5.6) | 5(6) |
| Fall down stairs | 7(6.9) | 1(5.6) | 6(7.2) |
| Fall from height | 9(8.9) | 2(11.1) | 7(8.4) |
| Assault | 2(2) | 0(0) | 2(2.4) |
| Other | 6(5.9) | 1(5.6) | 5(6) |

All studied patients were evaluated by ultrasound, urinalysis and ALT/AST. Among 101 enrolled patients 92 individuals had amylase test. Overall, 72/101 (71.3%) patients underwent abdominal CT-scan. All patients who did not undergo a CT- scan were discharged without a problem and did not have a problem in the follow up to two weeks later. According to results, 25 (24.8%) individuals had abnormal ultrasound, 28 (27.8%) individuals had abnormal urinalysis, 31 (30.7%) individuals had abnormal amylase level, 15 (14.9%) patients had abnormal ALT/AST, and 18 (17.9%) patients had abnormal physical exam (**Figure.2**).

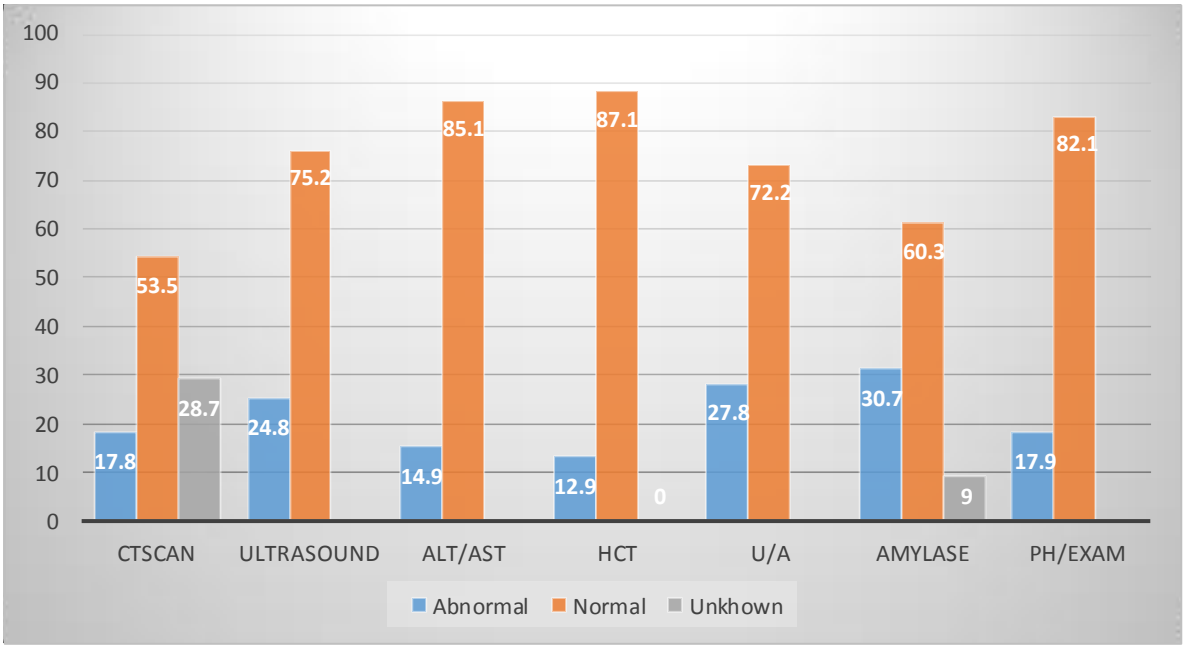


**Fig.2**: The frequency percentage clinical test results in studied patients.

In total, 18 patients (17.8%) were diagnosed with IAI, including 4 with injuries to more than 1 organ. The type of injury in these patients included bladder injury and severe bleeding one (5.5%), renal injury five (27.8%), liver injury eight (44.4%), splenic injury five (27.8%) gastrointestinal tract 1 (5.5%), pancreas two (11.1%). Two cases of splenic injury were transferred to operation room and three cases were observed. Just the patient with bladder rupture and two case of liver injury also were transferred to operating room. Thus 5 (5%) patients were diagnosed with IAI-I. The patient with bladder injury died later. A comparison of the ultrasound, physical examination, and results of four laboratory studies for children with and those without IAI is shown in **Table.3**. The children with IAI had a lower hematocrit (p=0.02), a higher concentration of ALT and AST (p<0.01), and more significant hematuria as detected by urinalysis (p=0.012). Concomitant abnormal ultrasound and ph/exam were more common among children with IAI (p<0.01). Eleven patients with IAI (61.1%) had an elevated AST/ALT whereas only 4 of patients without IAI (4.8%) had an abnormal AST/ALT (p<0.01). Six of the patients with IAI (33.3%) had a decreased HCT whereas only 7 of patients without IAI (8.4%) had a decreased HCT (p=0.02). Twelve of the patients with IAI (66.7%) had a documented abnormal abdominal exam whereas only 12 of the patients without IAI (11.1%) had an abnormal abdominal exam (p<0.01). Twelve of the patients with IAI (66.7%) had an abnormality on U/A, whereas 16 of patients without IAI (19.3%) had an abnormal U/A (p=0.012). Other variables, amylase was not statistically significant in predicting the presence of an IAI.

**Table-3**: The frequencies of abnormal tests between those with IAI and those with no IAI

| Abnormal values (%) | IAI (n=18) | No IAI (n=83) | P- value |
|---|---|---|---|
| AST/ALT | 11(61.1) | 4(4.8) | <0.01 |
| Ultrasound | 13(72.2) | 12(14.5) | <0.01 |
| U/A | 12(66.7) | 16(19.3) | 0.012 |
| HCT | 6(33.3) | 7(8.4) | 0.02 |
| Amylase* | 4(44.4) | 27(32.5) | 0.38 |
| Ph/Exam | 12(66.7) | 6(7.2) | <0.01 |

AST: aspartate aminotransferase; ALT: alanine aminotransferase; U/A: urinalysis; HCT: hematocrit; Ph/Exam: physical exam; *92 patients had amylase test.

Forty-six patients had an abnormality in at least one of the six variables. Of these, 21 had abnormalities in two or more of the variables. Our six clinical variables would have identified 18 of the 18 patients with IAI correctly (Se=100%). Regardless of ultrasound other five variables would have identified 17 of the 18 patients with IAI correctly (Se=94.4%). The patient not predicted by the variables sustained a grade I liver laceration which did not require surgical intervention and caused no major sequelae. The negative predictive patients with decreased HCT compared to those with normal HCT ($p < 0.05$). The odds of having an IAI was 15.4 times higher for patients with an abnormal ultrasound compared to those with a normal ultrasound ($p < 0.01$), and the odds of an IAI was 25.7 times higher for value of our variables with and without ultrasound was 100% and 98.2%. Odds ratios (and 95%CIs) for each of the six variables of interest in predicting IAI are demonstrated in **Table.4**. Of the 6 variables of interest, ultrasound, AST/ALT, hematocrit, abdominal examination, and U/A were related to IAI. The odds of having an IAI were 31.0 times higher for patients with an elevated AST/ALT than for those having a normal AST/ALT ($p < 0.001$). The odds of having an IAI were 5.4 times higher for those patients with an abnormal abdominal Ph/exam compared to those with no abnormality ($p < 0.01$). The odds of having an IAI were 8.4 times higher for those patients with hematuria compared to those with normal U/A ($p < 0.05$). Other factor (amylase) was not related to having an IAI.

**Table-4**: Univariate results from results of logistic regression models for prediction of Intra-Abdominal Injury

| Variables | OR | 95% CI | P value |
|---|---|---|---|
| Ultrasound | 15.38 | 6.11 – 67.81 | <0.01 |
| Physical Exam | 25.67 | 8.37 – 97.79 | <0.01 |
| ALT/AST | 31.04 | 10.11 – 150.72 | <0.001 |
| Amylase | 1.66 | 0.48 – 4.08 | 0.8 |
| Urinalysis | 8.37 | 1.33 – 41.65 | <0.05 |
| Hct | 5.43 | 1.62 – 26.73 | <0.05 |

OR: odds ratio; CI: confidence interval; AST: aspartate aminotransferase; ALT: alanine aminotransferase; U/A: urinalysis; HCT: hematocrit; Ph/Exam: physical exam.

According to the results, from 18 patients with IAI the ultrasound result of 13 (12.9%) patients was abnormal. Furthermore, from 83 patients with normal CT result or who did not undergo CT-scan, the ultrasound result was normal too for 71 individuals. Thus, sensitivity, specificity and positive predictive value and negative

predictive value of ultrasound compared to CT- scan were 72.2%, 85.5%, 52%, and 93.3%, respectively. Also, the accuracy of ultrasound was 83.2%. On the other hand, in 5 patients with abnormal CT scan, the ultrasound result was reported negative; however, in these patients the amylase and U/A results were abnormal. In 12 patients with IAI there were micro-hematuria (more than 5 RBC in every HPF), and from 83 patients without IAI, 67 individuals had normal urinalysis test. Thus, according to mentioned results, the urinalysis test had sensitivity of 66.7%, specificity of 80.7%, positive predictive value of 42.9%, and its negative value was 91.8%. The accuracy of U/A test was estimated as 78.2%. Among 101 studied patients 92 individuals had amylase test which 9 patients of them had abnormal CT- scan, four individuals had high amylase level, and 5 had normal amylase level (in nine patients with positive CT-scan, amylase test had not been performed but ultrasound and urinalysis were reported as abnormal). Furthermore, from 83 patients with negative CT-scan, 56 patients had normal amylase level and 27 individuals had high amylase level. Thus, concerning the mentioned results, amylase test had sensitivity of 44.4%, specificity of 67.5%, positive and negative predictive values of 12.9%, and 91.8% and its accuracy was 65.2%. According to the results, from 18 patients with IAI the ALT/AST result of 11 patients was abnormal, and from 83 patients without IAI, the ALT/AST result was normal for 79 patients. Thus, sensitivity, specificity and positive predictive value and negative predictive value of ALT/AST were 61.1%, 95.2%, 73.3%, and 91.9%. The accuracy of ultrasound was 89.1% respectively. The diagnostic value of each clinical variable for detection of IAI is demonstrated in **Figure.3**.

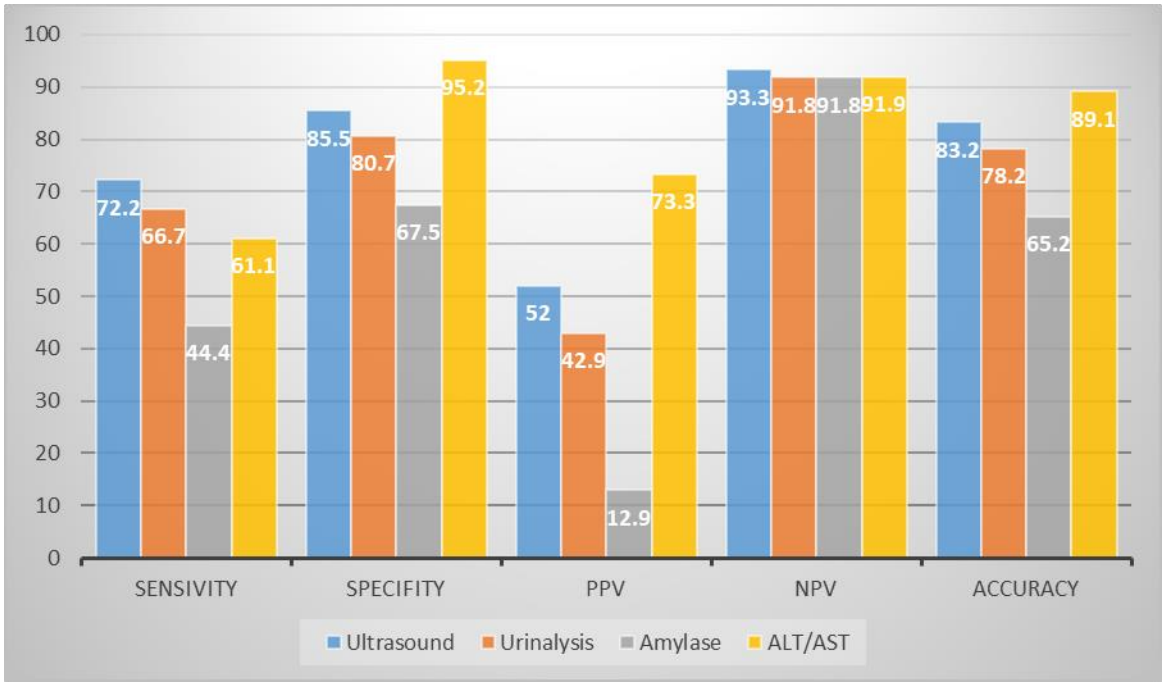


**Fig.3**: Diagnostic value criteria of ultrasound, liver function tests, urinalysis and amylase based on CT-scan.

AST: aspartate aminotransferase; ALT: alanine aminotransferase; PPV: positive predictive values; NPV: negative predictive values. In this study, 92 patients were evaluated by CT- scan, ultrasound,

ALT/AST, HCT, urinalysis and amylase tests. Four (4%) patients had positive results in all five tests and 55 patients (54.5%) had negative results in all tests. It is notable that all eighteen patients with positive CT-scan result (100%) had at least one positive test. Concerning the mentioned findings, the combination of ultrasound, ALT/AST, HCT, urinalysis and amylase tests (with at least one positive test) has negative predictive values of 100%.

## 4- DISCUSSION

The evaluation of children for IAI after BAT is more challenging than for an adult patient. Because of factors complicating the initial evaluation of children with BAT, a need exists for an accurate method of screening that leads to a low rate of missed IAI and avoids unnecessary imaging of children without IAI. The present study aimed to compare the diagnostic precision of ultrasound and CT-scan in diagnosis of abdominal injury of children with BAT and this study was to identify ultrasound and laboratory studies that accurately identify IAI while limiting unnecessary CT-scan among children without injury. In this study, 101 children suffering from BAT with average age of 6.75±3.2 years were studied.

All mentioned children were treated on discretion of the treating physicians and according to the CT protocols at each institution. In total, 18 patients (17.8%) were diagnosed with IAI, including 4 with injuries to more than 1 organ. The type of injury in these patients included bladder injury and severe bleeding one (5.5%), renal injury five (27.8%), liver injury eight (44.4%), splenic injury five (27.8%) gastrointestinal tract 1 (5.5%), pancreas two (11.1%). Two cases of splenic injury were transferred to operation room and three cases were observed. Just the patient with bladder rupture and two case of liver injury also were transferred to operating room. The patient with bladder injury died later. According to the results, sensitivity, specificity, positive predictive value and negative predictive value of ultrasound were obtained as 72.2%, 85.5%, 52.0% and 93.3% for diagnosis of IAI in children, respectively, and the accuracy of the mentioned test was 83.2%. Fox and Boysen obtained almost similar results from the study of ultrasound test in abdominal trauma in children. According to him, the positive predictive value of ultrasound is 45% and its negative value is 95% (23). Furthermore, in Raz et al.'s study, the sensitivity of ultrasound was 59%, specificity was 14% and positive predictive value was 48 % (24). In Kim et al.'s study, the ultrasound sensitivity was 61.3%, the specificity was 96.3% and the positive predictive value was 89.1% (25). Tobias et al. shown that the accuracy of ultrasound diagnosis in diagnosis of abdominal and pelvic traumas was estimated more than 97% which is higher than the accuracy of our study (26).

Thus, it can be concluded that ultrasound is a reliable tool for diagnosis of internal trauma in children and if there was no abdominal free fluid in the ultrasound it would be unlikely to suffer from serious problem as 93.3%. However, some patients with severe trauma might be missed in decision making only through this test. Thus, it is required to perform complementary and treatment measures for patients with negative result in ultrasound. One way to fully insure is to perform CT-scan in these patients, however, concerning lack of CT scan facilities in all health care centers and its high costs, if it is possible to make use of other complementary and reliable tests, it is possible to decide about the patient, reliably. According to the results, the urinalysis test had sensitivity of 66.7%, specificity of 80.7%, positive predictive value of 42.9%, and its negative value was 91.8%. Like our study Seyedhosseini-

Davarani et al. shown that hematuria has acceptable specificity, but very low sensitivity in comparison with CT scan for prediction of IAI in children with BAT (27). Another proposed solution is to use laboratory clinical tests such as urinalysis to determine hematuria (due to kidney and bladder damage), liver enzymes (in case liver injury is suspected), amylase and HCT. Thus, according to obtained results, if the results of ultrasound, urinalysis, amylase, HCT and liver enzymes had no sign of internal organs damages and the patients' status was satisfactory, it is possible to insure that patients would not suffer from serious injury and it is possible to decide on patients based on them. According to our study forty-six patients had an abnormality in at least one of the six variables. Of these, 21 had abnormalities in two or more of the variables. Our six clinical variables would have identified 18 of the 18 patients with IAI correctly (Se=100%). Regardless of ultrasound other five variables would have identified 17 of the 18 patients with IAI correctly (Se=94.4%).

The patient not predicted by the variables sustained a grade I liver laceration which did not require surgical intervention and caused no major sequelae. The negative predictive value of our variables with and without ultrasound was 100% and 98.2%, respectively. Concerning the mentioned findings, the combination of ultrasound, ALT/AST, HCT, urinalysis and amylase tests (with at least one positive test) has negative predictive values of 100%. Holmes et al. developed an algorithm for predicting IAI in children based on six variables: systolic blood pressure, abdominal examination, urinalysis, liver function tests, hematocrit, and the presence of a femur fracture (15). In this study, the use of one variable as a trigger for CT scan would lead to a scan in 55% of patients with a negative result in 46% of the studies. According to the results an elevated AST/ALT, a decreased HCT, a documented abnormal abdominal exam and an abnormality on U/A were significant in predicting the presence of IAI and amylase was not. Due to increased awareness of the risks of childhood irradiation, there have been several recent studies looking at alternative strategies to evaluate hemodynamically stable trauma victims based on clinical evaluation and laboratory analysis with only selective imaging. Cotton et al. reported a retrospective study assessing the utility of 23 clinical variables potentially associated with IAI in children (14). In a cohort of 351 patients, 42 patients (12%) had an identifiable IAI identified. Cotton et al. identified a number of factors that predicted IAI: abdominal ecchymosis (OR of 16), abdominal abrasions (OR of 17), tender abdomen (OR of 41), increase ALT, and decreased HCT. In all recursive partitioning models, like our study elevation in ALT/AST was identified as the most important variable predicting IAI. They advocate for a clinical prediction rule that combines physical exam with risk stratification based on elevated hepatic transaminases.

In the current study abnormal abdominal examination results predicted IAI, previous authors have noted physical examination to be inadequate and unreliable for evaluating children to detect IAI after BAT. These findings supported those of Allen et al. who demonstrated an increased incidence of hollow viscus injury (13.5%) in pediatric blunt trauma patients presenting with abdominal wall ecchymosis (28). Isaacman et al. observed that several studies addressing the inadequacy of physical examination appeared to be based on opinion and were not supported by accompanying data (29).

### 4-1. Limitations of the study

There are a number of limitations to this study. It was not possible to obtain

complete laboratory data for all the patients. Laboratory tests may have been selectively obtained for children with a high likelihood of IAI and not for those with low injury likelihood, another limitation of this study was the study sample size, the number of patients in the study was relatively small, and the number of identified injuries was low. A larger study that included more patients with IAI would be helpful to elucidate the relative value of these factors in a prediction model. However, due to the limitations of this study, it is recommended to conduct this study with higher sample size and widely to obtain more reliable results. Moreover, for higher reliability, the combination of ultrasound, U/A, and amylase tests can be used.

## 5- CONCLUSION

According to the results obtained from our study, the combination of three ultrasound tests, urinalysis and ALT/AST (with at least one positive test) has 100% sensitivity, 80.2% specificity, 0% false positive and 19.8% false negative. Furthermore, the positive and negative predictive values of the combination of three tests were obtained as 19% and 100%, respectively. It can be argued that ultrasound combined with selected laboratory studies can be used to predict the risk of IAI accurately among children who sustain BAT. Application of these findings may be useful in reducing costs and improving the accuracy of diagnosing IAI among children. The final conclusion of this study is that ultrasound has higher diagnosis value for determination of abdominal trauma in children with BAT and it can be used in centers which are not equipped with CT -scan.

## 6- CONFLICT OF INTEREST

The authors had not any financial or personal relationships with other people or organizations during the study. So there was no conflict of interests in this article.

## 7- ACKNOWLEDGMENTS

This study was supported by the Isfahan University of Medical Sciences, Iran (NO: 392292). The authors appreciate the insightful cooperation of Medical Sciences and the staffs of the emergency department of Al-Zahra and Kashani Hospital, Isfahan, Iran.

## 8- AUTHORS' CONTRIBUTION

All authors had four proposed criteria for the International Committee of Medical Journal Publishers to obtain a writer's condition.

## 9- REFERENCES

1. Schmidt TA, Dalo D, Hughes JA, Abbott JT, Geiderman JM, Johnson CX, et al. Confronting the ethical challenges to informed consent in emergency medicine research. Acad Emerg Med. 2004; 11:1082-9.

2. Arias E, MacDorman MF, Strobino Dlvl, Guyer B. Annual summary of vital statistics-2002. Pediatrics. 2003; 112:1215-30.

3. Heron M. Deaths: leading causes for 2007. Natl Vital Stat Rep. 2011;59:1-95.

4. Poletti P A, Kinkel K, Vermeulen B, et al. Blunt abdominal trauma: should US be used to detect both free fluid and organ injuries? Radiology. 2003; 227: 95-103.

5. Kirkpatrick AW. Clinician-performed focused sonography for the resuscitation of trauma. Crit Care Med. 2007; 35(5 Supp):S162-72.

6. Udeani J, SteinbergSR. Blunt abdominal trauma. eMedicine. Available at: http://emedicine. medscape. comlarticle/433404-overview. Accessed in Feb 20, 2011.

7. Meera TH, Nabachandra H. A study ofpattem and injury severity score in blunt thoraco-abdominal trauma cases in Manipal. Medico-Legal Update. 2005; 5:1-6.

8. Goletti O, Ghiselli G, Lippolis PV, Chiarugi M, Braccini G, Macaluso C, et al. The role of ultrasonography in blunt abdominal trauma: results in 250 consecutive cases; JTrauma. 2004; 36:178-81.

9. Brenner DJ, Hall EJ. Computed tomography—an increasing source of radiation exposure. N Engl J Med. 2007; 357:2277-84.

10. Patel JC, Tepas JJ Ill. The efficacy of focused abdominal sonography for trauma (FAST) as a screening tool in the assessment of injured children. J Pediatr Surg. 2009; 34:44-7.

11. Nural MS, Yardan T, Güven H, Baydin A, Bayrak İK, Kati C. Diagnostic value of ultrasonography in the evaluation of blunt abdominal trauma. Diagnostic and Interventional Radiology. 2005; 11(1):41.

12. Soudack M, Epelman M, Maor R, Hayari L, Shoshani G, Heyman-Reiss A, et al. Experience with focused abdominal sonography for trauma (FAST) in 313 pediatric patients. Journal of Clinical Ultrasound. 2004; 32(2):53-61.

13. Stengel D, Bauwens K, Sehouli J, Porzsolt F, Rademacher G, Mutze S, et al. Systematic review and meta-analysis of emergency ultrasonography for blunt abdominal trauma. British journal of surgery. 2001; 88(7):901-12.

14. Cotton BA, Beckert BW, Smith MK, Burd RS. The utility of clinical and laboratory data for predicting intraabdominal injury among children. Journal of Trauma and Acute Care Surgery. 2004; 56(5):1068-75.

15. Holmes JF, Mao A, Awasthi S, McGahan JP, Wisner DH, Kuppermann N. Validation of a prediction rule for the identification of children with intra-abdominal injuries after blunt torso trauma. Ann Emerg Med. 2009; 54: 528-33.

16. Holmes JF, Lillis K, Monroe D, Borgialli D, Kerrey BT, Mahajan P, et al. Identifying children at very low risk of clinically important blunt abdominal injuries. Annals of emergency medicine. 2013; 62(2):107-16.

17. Streck CJ, Vogel AM, Zhang J, Huang EY, Santore MT, Tsao K, et al. Identifying children at very low risk for blunt intra-abdominal injury in whom CT of the abdomen can be avoided safely. Journal of the American College of Surgeons. 2017; 224(4): 449-58.

18. Hutter M, Woltmann A, Hierholzer C, Gärtner C, Bühren V, Stengel D. Association between a single-pass wholebody computed tomography policy and survival after blunt major trauma: a retrospective cohort study. Scand J Trauma Resusc Emerg Med 2011; 19: 73.

19. Yeguiayan JM, Yap A, Freysz M, Garrigue D, Jacquot C, Martin C, et al. Impact of whole-body computed tomography on mortality and surgical management of severe blunt trauma. Crit Care 2012; 16: R101.

20. Huber-Wagner S, Biberthaler P, Haberle S, Wierer M, Dobritz M, Rummeny E, et al. Whole-body CT in haemodynamically unstable severely injured patients –a retrospective, multicentre study. PLoS One 2013; 8: e68880.

21. ACS. ATLS Student Course Manual. 9th ed. Chicago, IL: American College of Surgeons; 2012.

22. Smith CM, Woolrich-Burt L, Wellings R, Costa ML. Major Trauma CT scanning: the experience of a regional trauma centre in the UK. Emerg Med J 2011; 28: 378 –82.

23. Fox J C, Boysen M. Test Characteristics of Focused Assessment of Sonography for Trauma for Clinically Significant Abdominal Free Fluid in Pediatric Blunt Abdominal Trauma. Academic Emergency Medicine 2011; 18: 477-82.

24. Raz O, Haifler M, Copel L, Lang E. Use of Adult Criteria for Slice Irnaging May Limit Unnecessary Radiation Exposure in Children Presenting With Hematuria and Blunt Abdominal Trauma. Urology, 2011; 77: 187-90.

25. Kim Ch K, S Shin SD, Park Ch B. Diagnostic Accuracy of Focused Assessment with Sonography for Trauma (FAST) Examinations Performed by Emergency. Medical Technicians July-September 2012; 16(3): 400-6.

26. Tobias Re, Wolfgang H, Holger T, Udo R. Is sonography reliable for the diagnosis of pediatric blunt abdominal trauma? Journal of Pediatric Surgery 2010; 45: 912–15.

27. Seyedhosseini-Davarani S, Saeedi A, Rouhipour A, Sanei Taheri M, Baratloo A. The Value of Urinalysis in Detection of Abdominal Organ Injuries in Children with Hematuria Following Blunt Abdominal Trauma; a Diagnostic Study. International Journal of Pediatrics. 2017; 5(11):6103-10.

28. Allen GS, Moore FA, Cox CS, Wilson JT, Cohn JM, Duke JH. Hollow visceral injury and blunt trauma. J Trauma Injury Infect Crit Care. 1998; 45: 69–75.

29. Isaacman DJ, Scarfone RJ, Kost SI, Gochman RF, Davis HW, Bernardo LM, et al. Utility of routine laboratory testing for detecting intraabdominal injury in the pediatric trauma patient. Pediatrics. 1993; 92:691–94.