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U. Kaya, U. Y. Çavuş, M. E. Karakılıç, A. B. Erdem, K. Aydın, B. Işık, S. Abacıoğlu & F. Büyükcam

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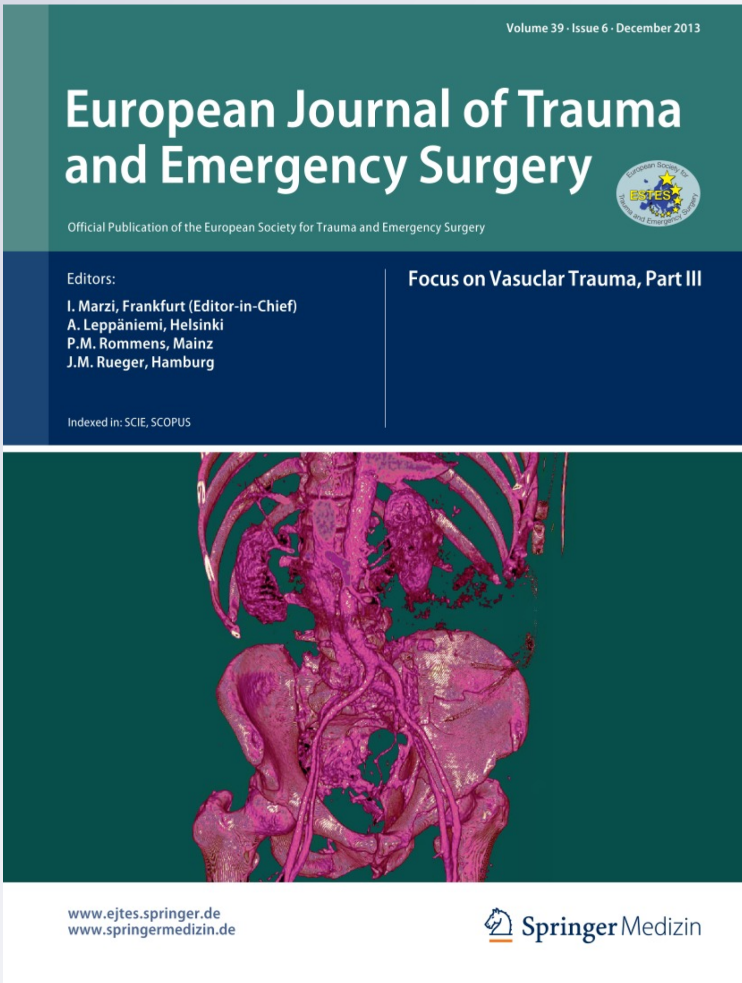

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ORIGINAL ARTICLE

Is computed tomography necessary to determine liver injury in pediatric trauma patients with negative ultrasonography?

U. Kaya · U. Y. Çavuş · M. E. Karakılıç · A. B. Erdem · K. Aydın · B. Işık · S. Abacıoğlu · F. Büyükcam

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Abstract

Purpose Abdominal trauma is the third most common cause of all trauma-related deaths in children. Liver injury is the second most common, but the most fatal injury associated with abdomen trauma. Because the liver enzymes have high sensitivity and specificity, the use of tomography has been discussed for accurate diagnosis of liver injury.

Methods Our study was based on retrospective analyses of hemodynamically stabil patients under the age of 18 who were admitted to the emergency department with blunt abdominal trauma.

Results Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) levels were significantly higher as a result of liver injury. In the patients whose AST and ALT levels were lower than 40 IU/L, no liver injury was observed in the contrast-enhanced computed tomography (CT). No liver injury was detected in the patients with AST levels lower than 100 IU/L. Liver injury was detected with contrast-enhanced CT in only one patient whose ALT level was lower than 100 IU/L, but ultrasonography initially detected liver injury in this patient.

Conclusions According to our findings, abdominal CT may not be necessary to detect liver injury if the patient has ALT and AST levels below 100 IU/L with a negative abdominal USG at admission and during follow-up.

Keywords Pediatric abdominal trauma · Liver enzyme · Liver injury · Ultrasonography

U. Kaya · B. Işık · S. Abacıoğlu
Department of Emergency Medicine, Zonguldak State Hospital, Zonguldak, Turkey

U. Y. Çavuş · K. Aydın · F. Büyükcam (✉)
Department of Emergency Medicine, Dışkapı Yıldırım Beyazıt Training and Research Hospital, Ankara, Turkey
e-mail: fatihbuyukcam@gmail.com

M. E. Karakılıç
Department of Emergency Medicine, Ankara Numune Training and Research Hospital, Ankara, Turkey

A. B. Erdem
Department of Emergency Medicine, Ankara Training and Research Hospital, Ankara, Turkey

Background

Abdominal trauma is the third most common cause of death in children after head and chest traumas [1]. Compared with adult patients, examination of the abdomen is more difficult and does not provide as clear information in pediatric patients. The presence of hypotension, abdominal tenderness and femoral fractures in patients with abdominal trauma should strongly suggest intra-abdominal injury [2]. If evidence of liver injury by physical examination and medical history is not available, but a high count of liver enzymes is found, then it is important to determine the necessity of abdominal computed tomography despite a negative abdominal ultrasonography result. Some studies have tried to find a threshold, but this issue has not otherwise received significant attention [3–7].

Although liver injury could be detected largely with abdominal ultrasonography, the gold standard method is contrast-enhanced abdominal computed tomography (CT) in abdominal traumas [8–10]. The limitations of abdominal computed tomography include the risk of aspiration of contrast material, contrast agent allergy, contrast nephropathy, delay due to transport of the patient, the need for sedation, and adverse effects of radiation on the child.

Furthermore, each abdominal computed tomography scan increases the lifetime risk of cancer by 0.18 % in 1-year-old infants [11].

In addition, abdominal CT scan may be insufficient in the diagnosis of injuries of the large and small intestines [12], and abdominal CT scan is not efficient in demonstrating perforations of the small bowel and pancreas [13, 14]. Furthermore, insisting on abdominal computed tomography in unstable patients and thus delaying laparoscopy may increase mortality [15]. Hemodynamically unstable patients with positive ultrasonography (USG) findings should be taken into laparotomy immediately without any additional diagnostic and radiological tests [16]. However, in hemodynamically stable patients with abdominal trauma, a detailed examination should be performed to assess intra-abdominal injury [17].

Many clinicians prefer abdominal computed tomography to avoid claims of malpractice, going to court and paying compensation, but these concerns have led to near-abusive levels of use for this method [18, 19]. Although new methods are under investigation to reduce the high use of abdominal CT scans, ultrasonography is still the safest and easiest way to evaluate children in the emergency department [20–22].

Assays of liver enzymes are rapid and inexpensive laboratory tests and are available in every center. Specifically, alanine aminotransferase (ALT) is a cytosolic liver enzyme and is released in response to necrosis of liver cells. ALT is voluminously present in the liver and kidney, whereas aspartate aminotransferase (AST) is present in liver, kidney, heart and muscular cells. Dufour et al. [23] on behalf of the U.S. National Committee for Biochemistry showed that ALT levels increase even more when compared to AST in liver defects, except in Reye's syndrome and alcohol-related liver injury.

With the knowledge that ultrasonography and liver enzymes are good methods for detecting liver injury, we wanted to find out if we could decrease the overuse of abdominal computed tomography in detection of liver injury in the pediatric population by using ultrasonography and liver enzyme analysis together.

Methods

In our study, we retrospectively analyzed the data of patients under the age of 18 with blunt abdominal trauma who were admitted to Dışkapı Yıldırım Beyazıt Training and Research Hospital Emergency Department between February 2, 2008 and December 31, 2010. The data for the patients who underwent both abdominal USG and abdominal CT were analyzed retrospectively. Pediatric patients with penetrating traumas were excluded. The AST, ALT and hemoglobin levels of the patients were compared with radiological findings. Whole abdominal USG was done by an emergency radiologist. Patients underwent USG and contrast-enhanced abdominal tomography within 30 min after arrival. Oral contrast was not given if bowel perforation was ruled out. We took only patients who underwent contrast-enhanced abdominal tomography because it is still the gold standard. However, our aim was to reduce the frequency of both contrast-enhanced and normal CT imagining because of high radiation levels involved with these procedures.

We used SPSS (Statistical Package for Social Science) 17.0 for Windows to analyze the data. The continuous variables are presented as mean, median and standard deviations; nominal variables were expressed as numbers and percentages. Histograms and the one-sample Kolmogorov–Smirnov test were used to evaluate whether the continuous variables were distributed normally. The significance of the difference between the independent variables and values that were not normally distributed was evaluated with the Mann–Whitney *U* test. The relationship between nominal variables was evaluated with Pearson's chi-square test" and Fisher's exact test, and $p < 0.05$ was considered to be significant. Sensitivity, specificity, negative predictive values (NPV) and positive predictive values (PPV) were calculated for the diagnostic tests.

Results

Ninety-eight patients were enrolled in the study. Seventy-one patients (72.4 %) were male, and the mean age was 8.39 ± 4.54 years. The average levels of AST and ALT were 243.07 and 144.03 IU/L, respectively. A summary of the general characteristics of the study population and the results of the tests are shown in Table 1. None of the patients had undergone surgery; all patients were discharged after conservative follow-up.

Contrast-enhanced abdominal CT has been accepted as the gold standard in the diagnosis of perihepatic fluid. For the diagnosis of perihepatic fluid with USG, the sensitivity was 79 %, the specificity was 95 %, the NPV was 92 %, and the PPV was 88 %. The AST and ALT levels were significantly higher in patients with perihepatic fluid ($p < 0.001$, for AST Z = 4.604, for ALT Z = 4.932). For the diagnosis of liver injury with USG, the sensitivity was 28 %, the specificity was 98 %, the NPV was 84 % and the PPV was 86 %. In patients with liver injury, the ALT and AST levels were significantly higher ($p < 0.001$, for AST Z = 6.157, for ALT Z = 6.348).

The relationship between contrast-enhanced abdominal CT and liver enzyme levels in detecting perihepatic fluid is shown in Table 2, and the relationship between contrast-

Table 1 General characteristic features of the study population ($n = 98$)

	Mean	Standard deviation	Median
Age	8.39	4.54	8.50
Plasma AST level	243.07	325.16	114.00
Plasma ALT level	144.03	221.64	62.00
Plasma amylase level ($n = 21$)	40.95	23.91	33.00
		Number	Percent
Sex	Male	71	72.4
	Female	27	27.6
Perihepatic fluid showed by USG	Present	26	26.5
	Absent	72	73.5
Liver injury showed by USG	Present	7	7.1
	Absent	91	92.9
Perihepatic fluid showed by CT	Present	29	29.6
	Absent	69	70.4
Liver injury showed by CT	Present	21	21.4
	Absent	77	78.6
Decrease in Hemoglobin level	Absent	70	71.4
	<2 unit decrease	12	12.2
	≥2 unit decrease	16	16.3
AST level	>40 IU/L	75	76.5
	≤40 IU/L	23	23.5
ALT level	>40 IU/L	53	54.1
	≤40 IU/L	45	45.9

enhanced abdominal CT and liver enzyme levels in detecting liver injury is shown in Table 3. The reliability values of these tests were given.

Of the patients who were not diagnosed with perihepatic fluid or liver injury with USG, no liver injury was observed using the contrast-enhanced CT in the patients whose AST and ALT levels were lower than 40 IU/L. Of the patients who were diagnosed with perihepatic fluid or liver injury with USG, no liver injury was detected in the patients with AST levels lower than 100 IU/L, and liver injury was detected in one patient with contrast-enhanced CT whose ALT level was lower than 100 IU/L. The contrast-enhanced CT findings of the patients who were diagnosed with free perihepatic fluid or liver injury with USG are shown in Table 4.

Other abdominal pathologies detected in our study patients were expressed in Table 5; in three patients pathologies are detected only by contrast-enhanced CT.

Discussions

Since abdominal CT was introduced in the 1980s, it has been the gold standard for the diagnosis of pediatric

Table 2 Liver enzyme levels in cases of liver injury diagnosed with abdominal CT

	Liver injury		p	χ^2	Sensitivity	Specificity	False positive	False negative
	Present	Absent						
AST > 40	21	57	0.009	6.853	1	0.259	0.730	0
AST ≤ 40	0	20						
ALT > 40	21	32	<0.001	22.693	1	0.584	0.603	0
ALT ≤ 40	0	45						
AST > 100	21	31	<0.001	26.643	1	0.597	0.596	0
AST ≤ 100	0	46						
ALT > 100	20	18	<0.001	35.892	0.952	0.766	0.473	0.016
ALT ≤ 100	1	59						

Table 3 Liver enzyme levels in cases of perihepatic fluid diagnosed with abdominal CT

	Perihepatic fluid		p	χ^2	Sensitivity	Specificity	False positive	False negative
	Present	Absent						
AST > 40	25	53	0.292	1.110	0.862	0.231	0.679	0.200
AST ≤ 40	4	16						
ALT > 40	24	29	<0.001	13.640	0.827	0.579	0.547	0.111
ALT ≤ 40	5	40						
AST > 100	24	28	<0.001	14.585	0.827	0.594	0.538	0.108
AST ≤ 100	5	41						
ALT > 100	23	15	<0.001	28.507	0.793	0.782	0.394	0.100
ALT ≤ 100	6	54						

Table 4 Comparison of the USG findings versus the abdominal contrasted-CT results at different liver enzyme levels

	Perihepatic fluid seen by USG				Perihepatic fluid not seen by USG			
	Perihepatic fluid[a]		Liver injury[a]		Perihepatic fluid[a]		Liver injury[a]	
	Present	Absent	Present	Absent	Present	Absent	Present	Absent
AST > 40	6	51	9	48	19	53	15	57
AST ≤ 40	0	15	0	15	4	15	0	19
ALT > 40	5	28	9	24	18	29	15	32
ALT ≤ 40	1	38	0	39	5	39	0	44
AST > 100	5	28	9	24	18	28	15	31
AST ≤ 100	1	38	0	39	5	40	0	45
ALT > 100	4	15	8	11	17	15	14	18
ALT ≤ 100	2	51	1	52	6	53	1	58

[a] Diagnosed with abdominal computed tomography

Table 5 Abdominal pathologies found in our patients except liver injury

	Detected only by USG	Detected only by contrast-enhanced CT	Detected by both USG and CT
Contusion of spleen	–	1	1
Laceration of spleen	–	1	1
Hematoma in kidney	1	1	–

abdominal trauma [24]. Given the diagnostic significance of contrast-enhanced tomography, the use of this method has steadily increased [19].

Because children are not able to describe symptoms as well as adults and due to the lack of clear examination findings, radiological diagnostic methods are important in diagnoses. Physical examination of pediatric patients has high sensitivity in detecting intra-abdominal injuries but has very low specifity [20]. In children, abdominal computed tomography is sensitive and specific in solid-organ injuries [24, 25]. Through the use of abdominal CT in children, the rate of laparotomy decreased and the rate of follow-up without operation increased. Fenton et al. [26] showed that among 897 pediatric abdominal trauma patients, surgery was needed in only 18 (2 %) of 310 patients with positive abdominal CT.

The liver is one of the most commonly injured organs and demonstrates the highest rate of mortality associated with intra-abdominal injury. However, conservative therapy is already satisfactory [2]. Landau et al. [27] retrospectively analyzed 311 children with blunt liver trauma. These researchers reported that only 4 % of the patients underwent laparotomy due to liver injury, whereas 93 % of the patients were treated successfully without surgery. The low complication and mortality rates demonstrated in this and other studies indicate that conservative treatment is successful in low-grade liver injuries and even in high-grade injuries with careful observation [28, 29]. The successful results of conservative approaches and reduction in the number of patients who underwent surgical intervention have led to debates on the need for abdominal computed tomography in detecting liver injury. Although abdominal ultrasound is effective in deciding whether emergency surgery should be performed, it is inadequate in the diagnosis of specific organ injuries [30–33]. However, utilizing the liver enzyme levels and USG together might be efficient in detecting the presence and level of liver injury. Demonstrating such an efficacy may reduce the need for contrast-enhanced abdominal CT for the detection of liver injuries.

Previous studies reported that USG has sensitivity ranging between 30 and 90 %, specificity between 77 and 100 %, PPV between 59 and 100 %, and NPV between 50 and 96 % in diagnosing abdominal injuries [34]. In our study, USG demonstrated 79 % sensitivity and 95 % specificity for detecting perihepatic fluid but only 28 % sensitivity and 98 % specificity in diagnosing liver injury. These findings are consistent with the literature [34].

Previously, various studies based on different threshold values for ALT and AST were performed [7]. In addition, when elevation of liver enzymes and positive ultrasound results were evaluated together, the sensitivity and specificity in terms of liver injury were significantly increased [7]. In our study, the ALT and AST values were significantly higher in patients with free perihepatic fluid. Similarly, the ALT and AST values were significantly higher in patients with liver injuries.

In the group of patients who were not diagnosed with perihepatic fluid or liver injury detected with USG, no liver injury was detected in the patients with AST levels lower than 100 IU/L, and contrast-enhanced CT detected liver injury in only one patient whose ALT level was lower than 100 IU/L; however, in this patient, ultrasonography diagnosed the liver injury. These data are consistent with the study of Bevan and colleagues, who reported 96 % sensitivity and 80 % specificity in determining intra-abdominal injury with ALT levels higher than 104 IU/L. In the same study, the sensitivity was 100 %, and the specificity was 70 %, in detecting only liver injury [3]. In the study of Karaduman et al. [5] the occurrence of intra-abdominal injury was significantly higher in patients with AST $>$ 100 and ALT $>$ 60 IU/L. For liver injury, these researchers found threshold levels of AST $>$ 500 and ALT $>$ 300 IU/L. In the study of Lee et al. [6] the sensitivity was 90 %, and the specificity was 92 %, for liver laceration in patients with WBC $>$ 10.000, AST $>$ 100 IU/L, and ALT $>$ 80 IU/L. In our study, when we considered ALT $>$ 100 IU/L as the threshold level, we observed 95.2 % sensitivity, 76.6 % specificity and 98.4 % NPV for liver injury and 79.3 % sensitivity, 78.2 % specificity and 99 % NPV for perihepatic fluid. When we considered AST $>$ 100 IU/L as a threshold, we observed 100 % sensitivity, 59.7 % specificity and 100 % NPV for liver injury and 82.7 % sensitivity and 59.4 % specificity for perihepatic fluid. Previously, Hennes et al. [4] found negative predictive values of 100 % (NPV) for the threshold values of AST 450 and ALT 250 IU/L. In the study by Cotton et al. at the threshold value of ALT 100 IU/L, these authors obtained 100 % specificity and 87 % sensitivity. In another study by Sola et al. [7] in which a threshold value of ALT 100 IU/L was accepted and combined with abdominal ultrasound, they obtained 88 % sensitivity, 98 % specificity and NPV of 96 %.

Conclusions

As a result, even though there are contradicting studies [35], our study demonstrated that the ALT and AST levels were closely related with liver injury. Other traumatic injuries except liver injury didn't change ALT and AST levels significantly. Although the sensitivity of USG was lower, when evaluated with ALT and AST levels, liver injury can be detected or excluded with specificity similar to contrast-enhanced abdominal CT. According to the results of our study, we suggest that contrast-enhanced abdominal CT scan is not indicated for detecting liver injury in hemodynamically stable pediatric patients with AST and ALT levels $<$100 IU/L without tenderness around the liver with a negative USG diagnosis.

Conflict of interest The authors certify that they have no affiliation with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the manuscript (e.g., employment, consultancies, stock ownership, and honoraria).

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