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Ultrasound versus computed tomography scan findings in pediatric blunt abdominal traumas

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Abstract: **Objective:** We aimed to evaluate the performance of ultrasonography (US) versus computed tomography (CT) scan in detecting intra-abdominal injury among pediatric patients with blunt abdominal trauma.
Methods: Pediatric patients aged<18, who were admitted to the emergency department (ED) due to blunt abdominal trauma and underwent both US and CT scan were evaluated retrospectively.
Results: A total of 732 pediatric patients were included in this study. Pathology was detected on US of 418 (57.1%) cases, whereas, intra-abdominal pathology was detected in CT scan of 359 (48.7%) cases. The sensitivity of US in detecting pathology (fluid and/or organ injury) was 95.3%, and its specificity was 79.6%. The sensitivity of US in detecting free fluid was 94.9%, and its specificity was 80.5%. In hemodynamically unstable and stable patients, the sensitivities of US in detection of pathology (fluid and/or organ injury) were 97.6% and 91.6%, and its specificities were 74.3% and 80.9%, respectively.
Conclusion: In our study, the sensitivity of US in terms of detecting pathology in pediatrics with blunt abdominal trauma was high, whereas the specificity of US was low.

Keywords: Abdominal Injuries; Computed Tomography; Non-penetrating Wounds; Pediatrics; Ultrasonography

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1. Introduction

In pediatrics, the abdomen is the third most common injury site after the head and extremities (1). There may be abdominal injuries in approximately 25% of major traumas, and blunt traumas account for >80% of abdominal traumas in childhood (1,2). The abdomen is the most common site of unnoticed fatal injuries, and the mortality rate in traumas accompanied by abdominal injury reaches up to 8.5% (3). Meanwhile, timely and accurate diagnosis of intra-abdominal injury following blunt abdominal trauma in pediatrics is difficult (4-6).
Ultrasonography (US) and computed tomography (CT) scan are the most commonly used radiological examination methods in pediatric patients admitted to emergency department (ED) due to abdominal trauma; and CT scan is the gold standard for the detection of intra-abdominal injury in critically injured children (1). CT scan has an important role in planning the treatment, because it shows intra-abdominal injuries and the degree of solid organ damages. However, presently, there is clear evidence that CT scan may expose the pediatric patients to high doses of radiation, which increases the risk of life-long radiation-related malignancies (7-10). In addition, the expenses, need for contrast agent, and lack of portability are considered as its limitations. Although CT scan is sensitive and accurate, it is not suitable for unstable patients (1,4).
US provides a quick and general overview of the peritoneal cavity to determine the presence of acute bleeding and free fluid, which is an indirect sign of visceral organ injury (7). Despite its prevalent use in the adult population, the use of US remains questionable in children due to limited evidence of its accuracy (1,4). In pediatrics, a thick capsule that surrounds the liver, spleen, and kidneys, limits bleeding during solid organ injuries and reduces the sensitivity of US in detection of a significant injury (2). There are studies supporting the use of US in pediatric traumas, whereas there are other studies questioning its benefits (11-17). In this study, we compared US and CT scan findings in children admitted to the ED due to a suspicion of abdominal injury. Thus, using the data of our hospital, we aimed to evaluate the performance of US in pediatric abdominal injuries.

2. Methods

2.1. Study design

This cross-sectional study was carried out in line with research regulations, including the approval of the Ethics Committee of our institute dated 28/05/2019 and numbered 64/06. Pediatric patients who were admitted to the ED of Diskapi Yildirim Beyazit Training and Research Hospital in Ankara, Turkey, due to suspected blunt abdominal trauma, between January 1st, 2015 and January 1st, 2018 were studied.

2.2. Study population

Patients under 18 years of age with suspected abdominal injuries based on the International Statistical Classification of Diseases and Related Health Problems-10 (ICD-10) diagnostic code (T04.1, T06.5, T07.0, T14.9) were eligible. The name of the patients who underwent both US and CT scan were extracted from the hospital automation system. CT scan was performed in patients with pathology detected on US or in patients with suspicious physical examination findings. Patients with penetrating injuries were excluded. Pericardial and pleural fluids were not included.

2.3. Definitions

Intraperitoneal free fluid detected on US was divided into two groups of "trace or minimal" and "moderate or large". Those with the amount of fluid measuring less than 1 centimeter (cm) in diameter were included in the "trace-minimal" group. The amount of fluid measuring 1 to 3 cm was considered moderate, while the amount of fluid measuring more than 3 cm was considered large.

2.4. Data gathering

Reviewing patients' medical file, the following data were recorded: demographic data (age, sex, and injury mechanism), injury sites determined during the first examination, vital signs on arrival at the ED, abdominal physical examination results, laboratory values, abdominal US findings, abdominal CT scan findings, and data on the treatments they received. Injury severity score (ISS), pediatric trauma score (PTS), and the Glasgow coma scale (GCS) scores were also calculated. The number of patients undergoing conservative or surgical treatment after the primary managements in the ED was determined.

Because of the retrospective nature of the study, we used US results obtained and officially reported by radiologists with at least two years of experience. These examinations were performed in supine position using the convex probe of the US device Esolute Mylab 60, and the patients' abdomen was investigated. During the examination, all quadrants of the abdomen from the xiphoid to pelvis were thoroughly evaluated. As per standard US procedure, the presence of the intra-abdominal free fluid was first examined; thereafter, the presence of intra-abdominal solid organ laceration was determined. The US screening of the patients with unstable hemodynamic status was performed as bedside assessment in the trauma resuscitation room.

After the US examination, the patients' abdomen was scanned from the diaphragm to pelvis using Toshiba Alexion 16 slice CT Scanner. Iohexol 300 mg I/mL was intravenously administered according to the patient's weight using an Imaxeon syringe. All captured images were recorded in the hospital's picture archiving and communication system (PACS). CT scans were interpreted and reported by radiologists.

2.5. Statistical analysis

For statistical evaluations, SPSS (IBM SPSS Statistics for Windows, version 24.0, SPSS Inc., Chicago, IL) and MedCalc (Med Calc Software, version 15, Mariakerke, Belgium) were used. The number of true positives, true negatives, false positives, and false negatives of US findings were determined in comparison to CT scan findings. Kappa analysis was performed for evaluating the statistical agreement between US and CT scan findings and the kappa coefficient was determined. Sensitivity, specificity, positive likelihood ratio (LR+), negative likelihood ratio (LR–), positive predictive value (PPV), and negative predictive value (NPV) of US findings were determined with 95% confidence interval (CI) using MedCalc statistical program.

3. Results

A total of 732 pediatric patients were included in this study. Pathology was detected on US of 418 (57.1%) cases, whereas, intra-abdominal pathology was detected in CT scan of 359 (48.7%) cases. Demographic and clinical characteristics of the patients are presented in table 1.

The comparison of intra-abdominal pathologies detected on US and CT scan is presented in table 2. Out of the 418 patients in whom pathology was detected on US, 342 (95.3%) had pathology on CT scan. Out of the 314 patients in whom pathology was not detected on US, 17 (4.7%) had pathology on CT scan. Emergency surgical treatment was performed in one of these 17 patients. US could not detect 55, 48, and 17 patients who had liver, spleen and renal injuries, respectively; whereas, CT scan could detect these injuries. The agreement between US and CT scan findings in all intra-abdominal pathologies was higher than 0.7.

The sensitivity of US in detecting pathology (fluid and/or organ injury) was 95.3% and its specificity was 79.6%. The sensitivity of US in detecting free fluid was 94.9% and its specificity was 80.5% (Table 3). Two-hundred forty-four (33.3%) of the cases in whom free fluid was detected on US were in the moderate-large group, and 147 (20.1%) of them were in the trace-minimal free fluid group. Meanwhile, there was no pathology on CT scan of 8 (3%) patients with moderate-large fluid in US. Also, 64 (43.5%) patients with trace-minimal fluid detected had no pathology on CT scan. Furthermore, the minimal amounts of free fluid detected in US reduced the

specificity of US.
The performance of US for solid organ injuries (liver, spleen and kidney) was separately examined. The sensitivity, specificity, PPV, NPV and accuracy of US were high for liver, spleen, and kidney injuries (Table 3).
In hemodynamically unstable patients, the false positive rate of pathology and free fluid detected on US were lower than those in hemodynamically stable patients. Moreover, the false negative rates were lower in hemodynamically stable patients. In patients with unstable and stable hemodynamic status, the sensitivities of US in detection of pathology (fluid and/or organ injury) were 97.6% and 91.6%, and its specificities were 74.3% and 80.9%, respectively (Table 4). In hemodynamically unstable patients, sensitivity and PPV were high, whereas in hemodynamically stable patients, NPV was high.
On US, 72 (19.1%) patients were found to have free fluid but no intra-abdominal injury. Of these, 20 (27.7%) had pelvic injuries. There was minimal-trace free fluid in 64 (89%) patients without organ injury.
Emergency abdominal surgery was performed in 18 (5.3%) patients with abdominal injury, whereas conservative treatment was planned for 341 (95%) patients. On US, no pathology was detected in one (5.5%) out of the 18 patients who underwent surgery. A total of 78.9%, 47.4%, 36.8%, 10.6%, and 5.3% (n=15, 9, 7, 2, and 1) of the patients who underwent surgery had liver, spleen, kidney, bladder, and bowel injuries, respectively. It should be mentioned that 6 patients had both liver and spleen injuries, 2 had liver, kidney, and bladder injuries, 2 had liver, spleen, and kidney injuries, and 1 had liver and kidney injuries concurrently.

Table 1 Demographic and clinical characteristics of the patients (n=732)

Variable	Number (%) / mean±SD (min-max)
Age (year)	7.2±5.5 (0-18)
Sex	
Male	442 (60.4)
Female	290 (39.6)
Mechanism of injury	
Intra vehicular traffic accident	194 (26.5)
Extra vehicular traffic accident	206 (28.1)
Fall from height	144 (19.7)
Drop of an object on the body	74 (10.1)
Bicycle accident	38 (5.2)
Motorcycle accident	21 (2.9)
Assault	26 (3.6)
Fall on flat ground	22 (3.0)
Others	7 (0.9)
Hemodynamic status	
Stable	447 (61.1)
Unstable	285 (38.9)
Injury severity score	15.2±14.7 (1-75)
Pediatric trauma score	6.5±3.8 (-6 - +12)
Glasgow Coma Score	12.4±3.5 (3-15)
The presence of pathology in US	418 (57.1)
The presence of pathology in CT scan	359 (48.7)
Liver injury on CT scan	205 (28.3)
Spleen injury on CT scan	152 (20.7)
Kidney injury on CT scan	62 (8.5)

SD: Standard deviation; US: Ultrasonography; CT: Computed tomography

4. Discussion

In this study, the performance of US versus CT scan in detecting intra-abdominal injuries among pediatric patients with blunt abdominal trauma were evaluated. We found that the sensitivity of US was high, whereas its specificity was low.
CT scan is important for evaluating intra-abdominal injuries and grading solid organ injuries in patients with blunt abdominal trauma. However, exposure to radiation needs to be considered in children (7). In a study performed on 3015 pediatric patients undergoing abdominal CT scan between 2007 and 2010, the intra-abdominal injury rate on CT scan was 5.8% (17). Studies conducted on children revealed that the rate of intra-abdominal injuries was 5.2%-29.7% (4). In contrast to these studies, the rate of intra-abdominal injuries detected in patients undergoing CT scan was high (49%) in the present study. The facts that our hospital is a pediatric trauma centre, the patients had high trauma scores, and there were efforts in our centre to reduce CT scan use in children may have had an effect on this result. Nevertheless, 3.4% of the patients for whom CT scan was performed, underwent emergency surgical intervention. Fenton et al. (18) reported that exploratory laparotomy was performed in only 2% of the children undergoing CT scan. Abdominal CT scan is important in pediatric abdominal trauma, especially in grading solid organ injuries. The reason for the prevalent use of CT scan is to determine the degree of injury and plan conservative treatment.
A meta-analysis published by Holmes et al. included 25 studies on the use of abdominal US in pediatric blunt trauma. For hemoperitoneum, ultrasound had a sensitivity of 80% (76%-84%), and specificity of 96% (95%-97%). The majority of studies (n=14) in this meta-analysis conducted by Holmes et al. were retrospective. In 18 of the studies, the physicians who performed US were radiologists (11). In another meta-analysis, US was determined to have a sensitivity, specificity, LR+ and LR- between 25%-80%, 77%-100%, 1.58-282, and 0.23-0.83, respectively (4). In these studies US was performed by emergency physicians and surgeons. In addition, all the patients included in these studies had stable hemodynamic status (4). In this meta-analysis, the sensitivity of US was low, and this result was attributed to the fact that hemodynamically unstable patients were not included in the studies. In the present study, there were both hemodynamically stable and unstable patients. In patients with stable hemodynamic, the sensitivity of US in detection of pathology (fluid and/or organ injury) based on CT scan findings as the gold standard was 92%, specificity was 81%, and accuracy was 85%. In our study, the sensitivity (98%) and accuracy (92%) of US were

Table 2 The comparison of intra-abdominal pathologies detected on ultrasonography and computed tomography scan

Intra-abdominal pathology (free fluid and/or organ injury) on US	Intra-abdominal pathology (free fluid and/or organ injury) on CT scan, n (%)		Kappa (95% CI)
	Positive	**Negative**	
Positive	342 (95.3)	76 (20.4)	0.747 (0.669 - 0.794)
Negative	17 (4.7)	297 (79.6)	
Total	359	373	
Free fluid on US	**Free fluid on CT scan, n (%)**		
	Positive	**Negative**	
Positive	319 (94.9)	72 (19.5)	0.749 (0.701 - 0.797)
Negative	17 (5.1)	297 (80.5)	
Total	336	369	
Liver injury on US	**Liver injury on CT scan, n (%)**		
	Positive	**Negative**	
Positive	150 (73.2)	3 (0.57)	0.787 (0.736 - 0.839)
Negative	55 (26.8)	524 (99.4)	
Total	205	527	
Spleen injury on US	**Spleen injury on CT scan, n (%)**		
	Positive	**Negative**	
Positive	104 (68.4)	11 (1.9)	0.731 (0.667 - 0.795)
Negative	48 (31.6)	569 (98.1)	
Total	152	580	
Kidney injury on US	**Kidney injury on CT scan, n (%)**		
	Positive	**Negative**	
Positive	45 (72.6)	3 (0.44)	0.804 (0.720 - 0.887)
Negative	17 (27.4)	667 (99.6)	
Total	62	670	

US: Ultrasonography; CT: Computed tomography; CI: Confidence interval

Table 3 The ability of ultrasound to detect pathology in comparison to computed tomography

Variable	Accuracy	Sensitivity	Specificity	PPV	NPV	LR+	LR-
				(95% CI)			
All pathologies	87.3(84.6-89.6)	95.3(92.5-97.2)	79.6(75.1-83.6)	81.8(78.6-84.6)	94.6(91.6-96.5)	4.7(3.8-5.7)	0.06(0.04-0.10)
Free fluid	87.4(83.7-89.9)	94.9(90.1-98.4)	80.5(76.2-84.8)	81.6(77.2-85.1)	94.6(91.3-97.1)	4.9(3.8-5.8)	0.06(0.03-0.10)
Liver injury	92.1(89.8-93.9)	73.2(66.6-79.1)	99.4(98.4-99.9)	98.0(94.2-99.4)	90.5(88.4-92.3)	128.5(41.5-398.5)	0.27(0.22-0.34)
Spleen injury	91.9(89.7-93.8)	68.4(60.4-75.7)	98.1(96.6-99.05)	90.4(83.9-94.5)	92.2(90.4-93.7)	36.1(19.9-65.4)	0.32(0.25-0.40)
Kidney injury	97.3(95.8-98.3)	72.6(59.8-83.2)	99.5(98.7-99.9)	93.8(82.8-97.9)	97.5(96.3-98.3)	162.1(51.9-506.5)	0.28(0.19-0.42)

PPV: Positive predictive value; NPV: Negative predictive value; LR+: Positive likelihood ratio; LR-: Negative likelihood ratio; CI: Confidence interval

Table 4 The ability of ultrasound to detect pathology based on the hemodynamic status of the cases

Ultrasonography	Hemodynamic Status	Accuracy	Sensitivity	Spesificity	PPV	NPV	LR+	LR-
				(95% CI)				
				All pathologies (Free fluid and/or organ injury) on CT scan				
All pathologies (Free fluid and/or organ injury)	Unstable	91.6(87.7-94.5)	97.6(94.6-99.2)	74.3(62.8-83.8)	91.6(88.0-94.1)	91.7(82.1-96.4)	3.8(2.58-5.60)	0.03(0.0.-0.07)
	Stable	84.6(80.9-87.8)	91.9(86.3-95.7)	80.9(76.0-85.2)	70.5(65.3-75.2)	95.3(92.1-97.2)	4.8(3.8-6.1)	0.1(0.06-0.17)
Free fluid	Unstable	92.2 (85.7-96.4)	97.8 (94.1-99.3)	75.7 (63.4-86.4)	91.8 (87.7-95.4)	92.0 (83.5-97.4)	4.1 (3.7-6.4)	0.03 (0.01-0.07)
	Stable	84.4 (79.7-88.6)	90.8 (85.4-96.8)	81.9 (75.4-86.4-7)	67.6 (56.4-72.6)	95.3 (92.0-97.8)	4.9 (4.1-6.2)	0.11 (0.55-0.16)
				Liver injury on CT scan				
Liver injury	Unstable	87.7 (83.4-91.3)	76.5 (68.4-83.3)	98.0 (94.2-99.6)	97.2 (91.9-99.1)	82.0 (77.1-86.1)	37.9 (12.3-116.9)	0.24 (0.18-0.33)
	Stable	94.8 (92.4-96.7)	66.7 (54.3-77.6)	100 (99.0-100.0)	100(99.0-100.0)	94.2 (92.1-95.8)	-	0.33 (0.24-0.46)
				Spleen injury on CT scan				
Spleen injury	Unstable	87.0 (82.6-90.7)	70.6 (60.8-79.2)	96.2 (92.3-98.5)	91.1 (83.1-95.6)	85.4 (81.3-88.8)	18.5 (8.8-38.6)	0.31 (0.23-0.42)
	Stable	95.1 (92.6-96.9)	64.0 (49.2-77.1)	98.9 (97.4-99.7)	88.9 (74.7-95.6)	95.6 (93.8-96.9)	63.4 (23.4-171.8)	0.36 (0.25-0.52)
				Kidney injury on CT scan				
Kidney injury	Unstable	95.1 (91.9-97.3)	73.9 (58.9-85.7)	99.2 (97-99.9)	94.4 (80.9-98.6)	95.2 (92.4-96.9)	87.9 (21.9-353.4)	0.26 (0.16-0.42)
	Stable	98.6 (93.8-99.2)	68.7 (55.7-78.8)	99.8 (98.7-99.9)	91.7 (84.9-96.5)	98.8 (93.4-99.7)	294.9 (123.4-547.7)	0.31 (0.21-0.58)

PPV: Positive predictive value; NPV: Negative predictive value; LR+: Positive likelihood ratio; LR-: Negative likelihood ratio; Cl: Confidence interval; CT: Computed tomography high in hemodynamically unstable patients. Patients with unstable hemodynamic status may have increased sensitivity of US. In another study, in which focused assessment with sonography in trauma (FAST) and shock index were combined, both positive FAST exam and shock index increased the PPV and specificity of FAST (5).

The sensitivity of US increases when hypotension occurs secondary to intra-abdominal bleeding. US sensitivity is improved in hemodynamically unstable patients (19). In a prospective observational study, the sensitivity of the free fluid detected in FAST for intra-abdominal injuries in children with hypotension was reported to be 100% (20). In a study by Holmes et al, 6% of the patients were hypotensive; in seven of whom free fluid was detected on US, and six of them were evaluated as normal. In all the seven patients with free fluid, intra-abdominal injury was detected. In one of the patients with normal US results, liver contusion was detected (20). Consistent with these findings, in our study, the sensitivity and accuracy rates of the presence of free fluid for intra-abdominal injuries in unstable patients was higher than stable patients.

In studies performed on pediatric traumas, the sensitivity and specificity of the free fluid on US for predicting the presence of intra-abdominal injuries were 56%-93% and 79%-97%, respectively (14,20-22). In a study by Scaife et al. (16), the sensitivity of the free fluid detected on US in predicting the presence of free fluid and/or organ pathology on CT scan was 44% and its specificity was 85%. In another study, the sensitivity of the free fluid on US in predicting the presence of intra-abdominal injury was 77%, its specificity was 70%, and NPV was 97% (23). In the present study, the sensitivity of the free fluid on US in predicting the presence of intra-abdominal injury was 95%, specificity was 80%, PPV was 82%, and NPV was 95%. As the amount of free fluid in the abdomen increases, the sensitivity of US to detect free fluid and pathology increases. Fox et al. (24) reported that the sensitivity of US in detection of moderate-large amount of free fluid was 52% and the specificity was 96%. In their study, sensitivity and specificity decreased when minimal free fluids were considered. In our study, 3% of the patients with moderate-large free fluid had no pathology on CT scan; whereas, 43.5% of the patients with trace-minimal free fluid had no pathology. According to the studies, it has been observed that false positivity rate of minimal free fluid in detection of abdominal injury is high in US. Another point that should not be ignored is that US devices with different sensitivities and doctors with different experience can affect US results. In patients with pediatric blunt abdominal trauma who are hemodynamically stable, if minimal fluid is detected in US, it would be more appropriate to keep the patient under observation for a while and then perform US again. The need for CT scan should be decided based on the patient's clinical condition and the second US result. Thus, unnecessary CT scans can be reduced in the patients.

It has been reported that 2%-10% minimal free fluid can be seen in US performed in asymptomatic children. Especially with the use of high frequency transducers, this rate can rise up to 22% (25-27). Jequier et al. (26) found fluid in the Morison pouch in up to 10% of asymptomatic children using high-frequency linear transducers. In asymptomatic children, this fluid is thought to originate from a layer of mesothelial cells covering the peritoneum that are capable of secreting and reabsorbing fluids (25-28). In our study, although free fluid was present in 19.5% of the patients, no significant organ injury was detected. However, the observation of this free fluid in trauma patients leads to prolongation of the observation time of children in the emergency department and further examinations. It should not be forgotten that pelvic fractures in trauma are the cause of free fluid. In addition, the presence of free fluid in the pelvic area in girls who are in puberty is physiological (24). Inferior vena cava, aorta, gallbladder, or intraluminal intestinal fluid may be mistaken with intraperitoneal fluid, thus producing a false positive result (29).

One of the limitations of US in detecting intra-abdominal injuries in children is the absence of free fluid in at least 25% of intra-abdominal injuries (6,29). In the study of Fox et al. (24), free fluid was not observed in 23% of the patients with intra-abdominal injuries. In the present study, there was moderate-large amount of fluid in 66% of patients with intra-abdominal injuries, trace-minimal amount of fluid in 23%, and no fluid in 11%. The low rate obtained in our study can be attributed to the performance of US by radiologists. In addition, drawing the conclusion that the examination is negative without evaluating all the gaps in a certain region in the abdomen leads to false negative results (29). Another reason for false negative results is the inability to reduce the gain when evaluating the pelvis, and therefore, the inability to identify intraperitoneal fluid behind the bladder due to posterior acoustic enhancement (29).

In a study by Calder et al. (19), the false negative rate of US for liver, spleen, and kidney injuries was 78.6%, 56.7%, and 66.7%, respectively. In a study by Mc Gaha et al. (5), the false negative rate was 65.1% for liver injuries and 27.8% for spleen injuries. In the present study, the false negative rates were 9.5%, 7.8%, and 2.9% for liver, spleen and kidney injuries, respectively. Zeeshan et al. (30) reported that the sensitivity of US in diagnosis of liver injury was 50%, specificity was 88%, and accuracy rate was 78%. In the present study, the sensitivity was 73.2%, specificity was 99.4%, and accuracy rate was 92% for this purpose. In the present study, the performance of US for detecting injuries in each of the solid organs was better in comparison with other studies. The facts that US was performed by radiologists and screenings were specifically performed for organ injuries may have affected the result of our study.

McGaha et al. (5) reported that the sensitivity of US in determining the need for emergency intervention was 76.2% and specificity was 60.5%. Calder et al. (19) reported that the sensitivity of detecting intra-abdominal injuries on FAST was 44.4%, its specificity was 88.5%, and its accuracy rate was 85% in predicting the need for emergency intervention. In the present study, 17 of the 418 patients with a positive FAST result underwent surgical intervention, whereas one of the FAST-negative patients underwent surgical intervention. The sensitivity of detecting free fluid via FAST in predicting the need for emergency surgery was high, whereas the specificity was low. The need for emergency laparotomy in children with blunt abdominal trauma depends on the patient's initial hemodynamic status and response to resuscitation. Presently, >90% of intra-abdominal injuries that occur due to blunt abdominal trauma are conservatively treated (7). There is an indication for emergency laparotomy in hemodynamically unstable patients who do not respond to resuscitation. In the present study, 6% of patients with intra-abdominal injuries underwent emergency surgery, whereas 94% of patients were conservatively treated. Conservative treatment is more prevalent in pediatric abdominal trauma patients than in adults. In conservative treatment, the hemodynamic status of the patient and the degree of solid organ injuries are important.

A positive result on US in trauma indicates hemoperitoneum and abdominal injury, whereas a negative result is not of much help in making decisions (24). In the present study, the false negative rate of pathology (free fluid and/or organ) on US was 5%. Surgical treatment was performed in one of the 17 patients for whom no pathology was detected on US. Both liver and spleen injuries were detected in the patient who underwent emergency abdominal surgery. The remaining 16 patients were conservatively treated. Although a negative US examination may miss a small percentage of patients with free fluid and/or parenchymal injuries, the clinical significance of these injuries is unclear considering that non-operative treatment of blunt abdominal trauma is a widely accepted practice in hemodynamically stable children. The use of US in evaluating pediatric trauma may not be enough to rule out injuries in patients, just like clinical examination, and it is recommended that pediatric patients be also evaluated via other methods (i.e. laboratory demands, clinical follow-up, and etc.) (31).

5. Limitations

The most important limitation of this study is that it is a retrospective study. Therefore, non-standardized US report results were used. The regions of the free fluids observed in US could not be determined (subxiphoid, hepatorenal, splenorenal, suprapubic). We were only able to include patients who had both US and CT scan imaging results recorded in the hospital automation system. Due to the large number of patients referring to our center and the scarcity of emergency physicians, the US was performed by radiologists.

6. Conclusion

In our study, the sensitivity of US was high, whereas its specificity was low. Therefore, primarily using US in pediatric patients with suspected abdominal trauma may decrease the rate of CT scan use in children. Patients with no ultrasound findings should be managed by considering their clinical status, trauma mechanism, physical examination findings, anatomical injury sites, physiological responses to trauma, and laboratory findings. Abdominal CT scan should be performed as an advanced test in patients with positive US findings.

7. Declarations

7.1. Acknowledgment

None.

7.2. Authors' contribution

HS: research question, data collection, statistical analysis, manuscript writing, and final editing; AB: research question, data collection, and manuscript writing; AH: data collection and manuscript writing; EDA: data collection and manuscript writing; SÖ: supervising the research team and final editing.

7.3. Conflict of interest

None declared.

7.4. Funding

None declared.

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