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Original article

Evaluation of intra-abdominal solid organ injuries in children

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Summary. *Aim:* In our study we investigated characteristics and degree of intra-abdominal solid organ injuries according to tomographic imaging in pediatric patients who presented to our emergency clinic with possible abdominal injuries and to whom US and/or abdominal tomography were applied. *Materials and Methods:* 1066 pediatric patients were included in the study. The age, gender, injury localization, injury type, injury mechanism, abdominal US and CT results, and treatment specifics of patients were evaulated. *Results:* 58.5% of cases were male. Average age of children was 7.1±4.6 70.8% of the injuries occured in the outdoors. As for injury type, 92.8% of the injuries were blunt and 7.2% were penetrating traumas. The most common mechanism of injury was motor vehicle accidents at 41.4%. The most common abdominal physical examination finding was tenderness with a prevelance of 67%. In patients with solid organ injury, liver injury was detected in 47% of patients, spleen injury was detected in 36% of patients and renal injury was detected in 17% of patients. Grade II injury was the most common grade. 96.5 of patients were provided conservative treatment and 3.5% of patients were treated surgically. *Conclusion:* Solid organ injuries due to abdominal trauma in children are generally related to blunt trauma and are severe injuries. CT angio is an important imaging method for detecting solid organ injuries, classification of the injury and treatment determination. Greater than 90% of solid organ injuries in children can be treated successfully with conservative methods. (www.actabiomedica.it)

Key words: child, abdominal injury, solid organ injury, treatment

Introduction and aim

Trauma is the most common cause of morbidity and mortality within the child age group. Abdominal traumas constitute 10-15% of children who visit the hospital with trauma (1). Abdominal traumas are the third most common trauma in children after head and extremity traumas. Blunt traumas constitute more than 80% of abdominal traumas in childhood. The most common cause is traffic accidents, followed by falling from elevated heights, bicycle accidents and child abuse. The most commonly injured organs are the spleen and liver (1-3). After the evaluation and resuscitation of trauma patients, a detailed physical examination should be made. As a single physical examination is not sensitive, serial physical examinations are required (2). In children, the absence of physical examination findings cannot exclude intra-abdominal injury. Despite normal physical examination findings, further tests and observation are needed in patients with high likelihood of intra-abdominal injury (2, 4). For children with abdominal injury who were admitted to emergency treatment, ultrasonography (US) and computed tomography (CT) are the most commonly used radiological tests. Sensitivity of US is between 56-97% for determining hemoperitoneum

in the intra-abdominal organ injury. CT is the gold standard in the diagnosis of abdominal injuries (1, 2). CT especially provides utility in planning conservative treatment and follow-up by classifying solid organ injuries in blunt abdominal injuries (1, 2). In our study, we aimed to investigate characteristics and the degree of intra-abdominal solid organ injuries according to tomographic imaging in child patients who consulted to our emergency clinic with possible abdominal injuries and to whom US and/or abdominal tomography was applied.

Materials and methods

Between 01.07.2012 and 01.07.2015, the data of children, who applied to our emergency service with potential abdominal injuries and had US and/or CT performed were retrospectively analyzed. Children under 18 years of age considered pediatric trauma in our center. We also included children under 18 years of age in our study. Age, gender, injury localization, injury type (i.e., blunt or penetrating), injury mechanism, injury areas in the first examination, abdominal physical examination results, follow-up duration in emergency service, abdominal US and CT results of included pediatric patients were recorded. Abdominal CT was performed on multiple trauma patients with pathologic findings on physical examination, pathology on abdominal US, and unconscious patients. Degree of CT organ injury of intra-abdominal solid organs were detected seperately as a number and percentage for liver, spleen and kidney. After the first patient intervention in emergency services, the number and percentage of conservative and surgical treatments were determined. Number and percentages of some results such as discharge from emergency service, exit from emergency service, admission to service, admission to intensive care unit and transfer to another hospital were determined. In statistical analysis, data were evaluated via SPSS 17.0 and Med Calc 15 statistics programs. $P<0.05$ was considered statistically significant. Number of patients was defined as (n) and percentage in all data was defined as (%). Detection rate, sensitivity and specificity of US in solid organ injuries were evaluated with ROC analysis.

Results

Total number of patients in the study was 1066. 58.5% were male (n=624) and 41.5% were female (n=442). Mean age of the patients was 7.14±4.60 years (min= 0; max= 18). 7.22% of cases were penetrating traumas and 92.78% were blunt trauma. 70.8% of injuries (n=755) happened outdoors, 15.1% (n=161) at school and 14.1% (n=150) happened at home (Table 1). Pediatric trauma score (PTS) average was determined as 7.4±2.6; Glasgow coma score (GCS) 12.9±2.8. Number of patients with 8 and greater on the pediatric trauma score was 433 (40.6%), and the number of patients who had PTS<8 was 633 (59.4%). Among injury mechanisms, motor vehicle accidents was the most common with a percent of 41.4%, and falling 19.7% (n=210) was the second most common. (Table 1). 12.1% (n=129) of the falls were falling from high, and 7.6% (n=81) were falling on flat ground. In physical examination findings of children, there was tenderness in 66.97% (n=714), abrasion in 48.8% (n=520), abdominal defence in 23.64% (n=252), rebound in 16.51% (n=176), laceration in 16.2% (n=173) and ecchymosis in 6.3% (n=67) of patients (Table 1). For 1009 cases among the included patients, abdominal US was performed with 63% of scans (n=632) abnormal. There was free fluid identified within the US in 62% of cases (n=625). Significant free fluid was seen in US at 249 of the cases. 376 of them had minimal or plaster-like free fluid. Of these 376 patients, 191 had abdominal CT scans and 77 solid organ injuries were detected. 185 patients without pathological findings on physical examination were followed in emergency trauma room. The blood and US examinations of these patients were repeated. Patients whose control values were normal were discharged to the emergency department.

There was liver injury in 9% of children (n=89), spleen injury in 6% of patients (n=66) and renal injury in 4% of patients (n=36) in US (Table 1). Detection of liver, spleen and renal injury in US was evaluated with ROC analysis. According to this, when detection of liver injury by US was evaluated according to ROC analysis, the AUC value was 0.78, specificity was 92% and sensitivity was 68%. AUC value of US was 0.79, specificity was 93% and sensitivity was

Table 1. Demographic characteristics of cases

	Mean±std dev	Min-max
Age	7.14±4.60	0-18
PTS	7.4±2.6	0-12
GCS	12.9±2.8	3-15
Systolic Blood Pressure (mmHg)	89.1±16.5	45-130
Diastolic Blood Pressure (mmHg)	64.1±9.6	30-88
Pulse (beats/min)	94.0±18.0	12-161
Respiratory rate (beats/min)	28.7±4.0	20-40
Oxygen saturation (%)	93.6±4.9	0-99
WBC (10^3/μL)	11.1±4.6	4.2-36.3
Hb (g/dL)	13.1±1.3	1.2-16.9
Hematocrit (%)	40.1±4.9	20.8-51.3
Plt (10^3/μL)	277.6±75.5	138-440
Blood urea nitrogen (mg/dL)	23±10.3	5-88
Creatine (mg/dL)	0.6±0.3	0-5
AST (UI/L)	138.4±351.8	6-3016
ALT (UI/L)	145.9±381.1	3-3369
	n	%
Mechanism		
Motor vehicle accident	441	41.4
Fall	210	19.7
Falling of objects on to the patient	140	13.1
Bicycle accident	129	12.1
Blow	66	6.2
Stab injury	64	6
Gunshot injury	11	1
Other	5	0.5
Other Injury Regions		
Head-neck	225	21.1
Thorax	247	23.2
Extremity	568	53.3
Pelvis	183	17.1
Genitourinary	113	10.6
Spine	80	7.5
Maxillofacial	242	22.7
Physical examination findings of cases		
Tenderness	714	67
Rebound	176	16
Defence	252	24
Ecchymosis	67	6.3
Abrasion	520	48.8
Lacerations	173	16.2
Findings of US		
Free Fluid	625	62
Liver injury	89	9
Spleen injury	66	6
Renal injury	36	4
Other organ injuries	19	1.9
Normal	377	37

(continued)

Table 1 ***(continued)*****.** Demographic characteristics of cases

	n	%
Findings of CT		
Normal	290	43.4
Liver injury	152	22.8
Spleen injury	115	17.2
Renal injury	53	7.9
Other organ injuries	69	10.3
CT injury degrees of Liver		
Grade I	39	26
Grade II	62	41
Grade III	31	20
Grade IV	18	12
Grade V	2	1
CT injury degrees of Spleen		
Grade I	33	28
Grade II	48	42
Grade III	16	14
Grade IV	18	12
Grade V	1	1
CT injury degrees of Kidney		
Grade I	3	6
Grade II	25	47
Grade III	12	23
Grade IV	8	15
Grade V	5	9

PTS: pediatric trauma score, GCS: Glasgow coma score, AST: aspartate aminotransferase, ALT: alanine aminotransferase

70% in detecting spleen injury. AUC value of US was 0.81, specificity was 92% and sensitivity was 75% in detecting renal injury (Table 2). Abdominal CT was taken from 668/1066 patients (63%) in our study. Among these patients, 43% (n=290) were normal and 57% were not normal (n=378). There was liver injury in 23% of children (n=152), spleen injury in 17% of children (n=115) and renal injury in 8% of children (n=53). In abdominal CT, other organ injuries included bladder (n=35), gastrointestinal tract(n=14), urethra (n=8), ureter (n=12) (Table 1). Among patients with solid organ injury, liver injury was detected in 47% of patients, spleen injury was detected in 36% of patients and renal injury was detected in 17% of patients. In patients with liver, spleen and renal injuries, second degree injuries were most frequently observed. CT injury degrees and percentages of intra-abdominal solid organs are given in table 1. Mean follow-up duration of patients in emergency service was 8.9±2.8 hours. 77.1% of patients were given fluids (n=822), 10.2% (n=109) were given erythrocytes or other blood products, 85.8% (n=915) were given drug treatment,

Table 2. ROC Analysis of US in determining solid organ injuries

	AUC	95% Confidence interval	Specificity	Sensitivity	SE
Liver	0.78	0.746-0.810	92%	68%	0.0200
Spleen	0.79	0.758-0.821	93%	70%	0.0221
Kidney	0.81	0.774-0.836	92%	75%	0.0292

8.5% (n=91) were setup with mechanic ventilation. 99.5% of patients (n=1061) were given other treatments such as plaster, splints, suture, dressing, tetanus immunizations, tube thoracostomy, central catheters, and intraosseous treatment. 47.5% of patients (n=506) were discharged from emergency service at the end of the treatment provided in the emergency department. Patients whose free fluid was detected in US of the abdomen but whose CT was normal were discharged after follow-up in the emergency department. The proportion of patients who died in the emergency department 2.8% (n=30). 20.4% (n=217) of patients were sent for trauma-related service (pediatric surgery, orthopedics, neurosurgery) following completion of immediate medical interventions and the observation period. 17.3% of patients (n=184) were hospitalized in the trauma-related intensive care unit at the end of the first intervention and observation period in the emergency department. 12.1% of the patients (n=129) were transferred to another hospital via ambulance due to lack of available space in our hospital and intensive care. 8.2% of 378 cases with intra-abdominal solid organ injury (n=31) were taken into surgery while 91.8% (n=347) of them were treated with conservative methods. Selektif embolization is performed in our center. But no patient had performed selective embolization. Treatment and final outcomes of cases according to degree of solid organ injury are given in Table 3.

Discussion

In our study, the types of abdominal traumas were blunt trauma (93%) and penetrating traumas (7%), which were compatible with literature data. Physical examination findings in patients with abdominal trauma are important. In particular, rebound during abdominal examination indicates that abdominal trauma can be severe. In studies, abdominal tenderness, rebound and defense were reported with a prevalence of 70-75%, 19-21%, and 25-39%, respectively (5, 6). In the study of Jong et al., peritoneal irritation was reported in 19% of all patients and in 27.8% of patients with abdominal injury (7). In our study, the most common

Table 3. Treatment and final outcomes of cases according to solid organ injury degrees

	Blood tranfusion n (%)	Ventilator support n (%)	Surgical treatment n (%)	Conservative treatment n (%)	Service hospitalization n (%)	ICU hospitalization n (%)	Mortality n (%)	Transfer another hospital n (%)	Discharge n (%)
Liver									
G-I	5 (13)	5 (13)	2 (5)	37 (95)	16 (41)	11 (28)	1 (3)	11 (28)	
G II	9 (15)	13 (21)	4 (6,5)	58 (93.5)	11 (18)	27 (43.5)	4 (6.5)	20 (32)	
G III	7 (23)	9 (29)	2 (6,5)	29 (93.5)	3 (10)	15 (48)	3 (10)	10 (32)	
G IV	8 (44)	9 (50)	6 (33)	12 (67)	-	9 (50)	4 (22)	5 (28)	
G V	2 (100)	-	2 (100)	-	-	2 (100)	-	-	
Spleen									
G I	5 (15)	4 (12)	1 (3)	32 (97)	12 (36)	13 (39)	-	8 (24)	
G II	16 (33)	12 (25)	6 (12,5)	42 (87.5)	10 (21)	20 (42)	2 (4)	15 (31)	1 (2)
G III	9 (56)	10 (62.5)	2 (12,5)	14 (87.5)	1 (6)	5 (31)	4 (25)	6 (43)	-
G IV	11 (65)	11 (65)	5 (29)	12 (71)	-	8 (47)	6 (35)	3 (18)	-
G V	1 (100)	1 (100)	-	-	-	-	1 (100)	-	-
Kidney									
G I	1 (33)	1 (33)	-	3 (100)	-	1 (33)	-	1 (33)	1 (33)
G II	5 (20)	7 (28)	-	25 (100)	5 (20)	7 (28)	3 (12)	9 (36)	1 (4)
G III	6 (50)	4 (33)	2 (17)	10 (83)	1 (8)	4 (33)	-	7 (58)	-
G IV	6 (75)	4 (50)	6 (75)	2 (25)	-	6 (75)	1 (12.5)	1 (12.5)	-
G V	5 (100)	5 (100)	2 (40)	3 (60)	-	2 (40)	3 (60)	-	-

G: grade, ICU: Intensive Care Unit

physical examination finding in patients was tenderness at 67%. In our study, defense was detected in 24% of patients and rebound was detected in 16% of patients. These percentages were compatible with the literature. Physical examination findings in pediatric trauma patients can be generally illusive. Absent or mild physical examination findings cannot exclude intra-abdominal injury. Despite normal physical examination findings, further testing and follow-up should be made for the patients with a strong likelyhood of intra-abdominal injuries (2, 4). Spleen and kidneys are most commonly affected in blunt traumas whereas the gastrointestinal tract is most commonly affected in penetrating traumas (2). It was reported that the liver is the second most commonly injured organ following the spleen in blunt traumas and the small intestine in cutting injuries (1, 2, 8). Wisner et al., investigated a total 605 children with solid organ injuries and found spleen injury in 49% of these children, liver injury in 47% and renal injury in 24% of these patients (9). On the other hand, our study found that the most commonly injured organ (n=320) was the liver in47% of patients followed by injury of the spleen and kidney in 36% and 17% of patients, respectively. When we compared ours toother studies, they differed as ours had liver injury as the most common. US sensitivity for determining hemoperitoneum is 56-97% (1, 2, 10). Imaging value of US for other organ and retroperitoneal injuries is lower (2, 4). Er et al., found in their study that sensitivity of focused assessment with sonography in trauma (FAST) for detecting solid organ injury or free fluid in CT is 50% and specificity is 85% (11). In a study of Ben Ishay et al., sensitivity, specificity and AUC value of FAST for detecting intra-abdominal solid organ injury was 77%, 70% and 0.66%, respectively (12). On the other hand, sensitivity, specificity and AUC value of US for detecting liver injury in our study was 68%, 92% and 0.78%, respectively. Sensitivity, specificity and AUC value of US for detecting spleen injury in our study was found as 70%, 93% and 0.79%, respectively. In our study, sensitivity, specificity and AUC value of US for detecting renal injury was found as 75%, 92% and 0.81%, respectively. In our study, detection of the degree of organ injury by US was found as high as in the Ben Ishay et al. (12) study. High percentages can be due to quality of devices and experience of operators.

50-70% of hepatic injuries as a result of blunt abdominal trauma are Grade I and II; 5% of them are Grade IV and V (8). In a study of Leone et al., Grade I, II, III, and IV injuries were detected 49%, 33%, 11%, 7%, respectively (13). In study of Wisner et al., Grade I, Grade II, Grade III-IV injuries were detected 25%, 32% and 43% of the time, respectively (9). In our study, Grade I and II injuries were detected 26% and 41% of the time, respectively, which was compatible with the literature. On the other hand, Grade IV and V injuries were found in only12% and 1% of cases, respectively and their percentages were higher than in other literature. Percentage of our patients with Grade III liver injury was 20%. We believe that the high proportion of severe injuries in our study might be due to the transfer of severely injured patients to our emergency clinic as we are the only pediatric trauma center in our region. According to the American Association for the Surgery of Trauma organ injury scale for spleen injuries as a result of blunt abdominal trauma, 25.8% were Grade I, 32.2% were Grade II, 29% were Grade III and 12.9% were Grade IV (8). In the Wisner et al. study, 18% Grade I, 25% Grade II, and 57% Grade III-VI injuries were detected (9). In our study, the spleen was the second most common solid organ that was injured. 42% of cases were Grade II injuries, which was compatible with the literature. This was followed by Grade II (28%), Grade IV (15%), Grade III (14%), and Grade V (1%). These data were also compatible with other literature. Hemodynamic stability is the most important measure for the indication of conservative treatment. Similar to our study, cases with well chosen Grade IV splenic injury can be successfully treated without surgery (Table 3). Grade I injuries including only parenchymal rupture and hematoma without an expansion trend constitute 80-85% of total renal injuries. Such injuries can be treated with bedrest (14, 15). Grade II and III injuries have a percentage of 10-15% and resolve spontaneously as contusions. Grade IV and V injuries occur in 5% of the cases (14, 15). In the study of Wisner et al., 36% Grade I, 22% Grade II, and 42% Grade III-VI injuries were detected (9). In the study of Henderson et al., the percentageof Grade I-II cases in renal injury due to blunt trauma was 60% and 40% for Grade IV-V patients (16). In our study, which was compatible with the literature, minor

renal injuries were significantly (76%) increased. Major injuries (grade IV ve V) were seen with proportion of 24%. Our high incidence of major injury is due to our center serving as a = pediatric trauma center in our city. In 90% of children with blunt abdominal trauma, urgent surgical intervention is not needed; instead, close monitoring and intensive care is indicated (17). In our study, 96.5% of patients with intra-abdominal solid organ injuries were treated with conservative methods and 3.5% of them were taken into surgery. These rates are compatible with the literature. As the liver is fed from both the systemic and portal veins, extensive bleeding can occur, requiring additional surgical intervention (18). In our study, RBC and/or other blood product treatments were given to 30 children with liver injuries. In liver injuries, general laparotomy occurrence is 8%. Laparotomy is indicated due to complications in 4% of cases (14, 19). In our study, which is compatible with the literature, surgery was performed on 9.9% of children with liver injury. 90.1% of cases were treated conservatively. In spleen injuries, hemo transfusion is needed in about 25-40% of patients (20). In our study, which is compatible with the literature, RBC/blood transfusion was given to 38.3% of patients. In all spleen traumas, splenectomy is required in 3-5% of cases (1, 9, 14). With conservative treatment, more than 90% of children can be treated completely (2). In the study of Wisner et al., the prevalence of splenectomy was reported as 7.4% (9). In our study, the total laparotomy percentage was calculated as 11.3%. We believe that this high prevelance of surgical indication is due to admission of severe trauma patients to our hospital and other concomitant injuries. Our percentage of patients who were followed with conservative treatment was 88.7%. Renal injuries are generally seen due to blunt traumas and 90% of them are mild injuries that can be treated with conservative treatment. It was reported that conservative treatment can reduce mortality with low complication rates (21). In the treatment of renal blunt trauma in children, surgical treatment is rarely needed unless the presence of a fragmented renal or pedicle injury is present (21). In literature, surgical treatment percentagesare reported as 8-31% and conservative treatment percentages are reported as 70-92% (18, 22, 23). More commonly in recent studies, the surgery ratio is low. In the study of Henderson et al., prevelance of surgery was reported as 8.7% (18). In the study of Rogers et al., 10% of patients with a high injury grade (Grade IV) were taken into surgery and 80% of them were conservatively treated (24). In our study, 44 children with renal injury (83%) were followed-up with conservative treatment and in 9 children (17%), a surgical approach was applied. These findings are compatible with studies mentioned above and with other literature.

The most common cause of death in pediatric patients with multiple traumas is severe head trauma (2). In our study, head and neck injury was observed in 30.9% of children with liver injuries, in 33.9% of children with spleen injuries and in 30.2% of children with renal injuries. Accompanying head injury affected both surgery rate and mortality rate.

In conclusion, solid organ injuries due to pediatric abdominal trauma are generally due to blunt traumas and are severe injuries with high morbidity and mortality. CT angio is an important imaging method for detecting solid organ injuries, classifying the injuries and determining the indicated treatment type. Greater than 90% of pediatric solid organ injuries are successfully treated with conservative methods.

Compliance with Ethical Standards

We have received permission from the local ethics committee for this research. This study is retrospective/patient file research. So there is no patient consent form.

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