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Can we reduce CT scan and hospital costs in children with blunt trauma using four parameters?

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Abstract

Background: Blunt trauma is one of the most common causes of admission to the emergency service in childhood. Children with trauma are generally evaluated in emergency services where pediatric and adult patients are together, and difficulties are experienced in managing children exposed to trauma. CT is preferred for quick detection and grading of toracoabdominal, skeleton, and neurological injury in high energy trauma. The present study aims to determine the severity of trauma and whether CT exposure can be reduced and patient cost using four parameters.

This study was conducted with 586 pediatric patients exposed to blunt abdominal trauma. The clinical prediction rule consisted of four parameters, including abdominal pain, physical examination findings, aspartate aminotransferase (AST), and chest x-ray (CXR, which was used to predict intraabdominal injury in patients with blunt trauma. Patients with no parameters of the clinical decision rule were considered very low risk, and those with one or more parameters were considered at risk. The hospital cost of the patients with and without clinical decision rule was calculated and compared.

Results: In our study, according to the four-variable clinical prediction rule, 88.1% of the patients had a very low risk of intraabdominal injury and 11.9% of them were at risk. The sensitivity was 97.3%, specificity 98.2%, and accuracy was 97.4% in very low-risk patients with four variables clinical prediction rule. In the very low-risk patients, the abnormal CT rate was 0.3% and conservative treatment was performed. With the use of four variables, 0.17% of solid organ injuries may be overlooked. In the risk of patients, 2.9% of these patients were abnormal CT findings, while tube thoracostomy was performed in four patients with pneumothorax, conservative treatment was performed in other patients.

It was determined that routine computed tomography scan increased the patient cost by 5.5 times.

Conclusion: Patients exposed to blunt trauma with a very low risk of intra-abdominal injury can be identified with a four-variable clinical prediction rule. According to the four-variable clinical prediction rule, very low-risk patients do not require immediate CT. The hospital costs can be reduced by reducing the CT scan. However, it should be kept in mind that a small proportion of intra-abdominal injuries may be overlooked.

Keywords: Blunt abdominal trauma, Clinical decision rule, Childhood blunt trauma, Cost analysis

Background

Blunt trauma is one of the most common causes of admission to the emergency service in childhood. Children with trauma are generally evaluated in emergency services where pediatric and adult patients are together, and difficulties are experienced in the management of children exposed to trauma. While examining other

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systems such as the head and thorax in patients with blunt trauma, abdominal computed tomography (CT) is usually performed in emergency services not to miss possible intra-abdominal injury [1]. Although CT is one of the best imaging methods for evaluating intra-abdominal injury after trauma, it has disadvantages such as exposure to radiation, difficulty in transportation, and high hospital costs [2]. When making a CT scan decision, it should be considered that the risk of cancer development in children due to radiation is higher than in adults [1, 3–8]. Approximately 90% of patients with blunt trauma are treated nonoperatively and CT does not affect the treatment method in most patients [9]. Therefore, it has been suggested that CT should be preferred in patients with high intra-abdominal injury risk [1, 6, 7]. With the history, physical examination, complete blood count, urinalysis, and laboratory tests such as hepatic transaminases, pancreatic enzymes, conventional radiographs, and Focused Assessment with Sonography for Trauma (FAST) results are an idea about the severity of intra-abdominal injury and trauma can be obtained [1, 8–14]. This study aims to determine the severity of trauma in children using four parameters. The second aim is to investigate whether CT exposure can be reduced by applying the prediction rule. The final aim is to assess patient cost using four parameters.

Methods

Data of 586 patients who were exposed to blunt abdominal trauma between the ages of 18 months and 17 years, who were admitted to the emergency department of our hospital between April 2019 and October 2020, were retrospectively analyzed in this study. Patients with isolated head, extremity, or genital trauma, patients who were admitted 6 h after the trauma, those who underwent a CT scan in another center, who underwent peritoneal lavage, and who had incomplete data were excluded from this study. The present study was approved by the Institutional Ethics Committee.

In our study, intra-abdominal injury in patients with blunt trauma was tried to be predicted using the clinical prediction rule that includes four parameters: (1) abdominal pain, (2) abnormal physical examination finding (abdominal wall trauma sign, distension, tenderness, rebound tenderness), (3) AST > 200 IU/L, and (4) abnormal CXR (contusion**,** pneumothorax, hemothorax, rib fracture). According to the results of clinical prediction rule, patients were divided into two groups as very low risk and risk for intra-abdominal injury. Patients with no parameters of the clinical decision rule were considered very low risk, and those with one or more parameters were considered at risk. The necessity of urgent CT imaging in very low-risk patients according to clinical decision rules was questioned.

Age, gender, trauma mechanism, hospital admission period after trauma, abdominal pain, physical examination findings, hemogram and biochemistry values, conventional radiography, FAST, and CT reports were recorded on the patient evaluation forms prepared for the present study. The treatments were applied, and duration of hospital stay and results were evaluated. Abdomen CT findings were evaluated in five categories as contusion in solid organs, hematoma, laceration, intraperitoneal fluid, and intraperitoneal free air. FAST reports were evaluated as contusion, hematoma, and intraperitoneal fluid in solid organs. The management of the patients was grouped as observation in the emergency service, pediatric surgery service, or admission to the intensive care unit. The hospital cost of the patients with and without clinical decision rule was calculated and compared.

Seven days following the discharge, the families of the patients were contacted by telephone [6]. For patients who cannot be reached by phone, medical records were reviewed during the same follow-up period. The results of the clinical rule for measuring sensitivity, specificity accuracy, negative predictive values (NPV), and positive predictive values (PPV) were compared to a determined 7 days follow-up period without deterioration of traumatized patients after discharge.

Statistical methods

The data obtained from this research were statistically analyzed using SPSS (SocialSciences software package version 22.0 Windows) software program. Categorical variables were specified as number (*n*) and percentage (%). Numerical variables with normal distribution were shown as mean ± standard deviation. Multiple regression analysis was performed to assess the prediction of intra-abdominal injury of a clinical prediction rule. $P < 0.05$ was considered statistically significant. The sensitivity, specificity, positive and negative prediction, negative probability, and accuracy of the four-variable clinical prediction rule were calculated in patients with and without intra-abdominal injury.

Results

Of the 586 patients included in this study, 376 were males, 210 were females, and the mean age was 10.1 ± 5.7 years (18 months–17 years). In this study, 90.9% of the patients were brought to the hospital 1 h after the trauma and 9.1% 2 to 5 h after the trauma. The abnormal CT rate was 3.2%, and the abnormal rate FAST was 4.4% of patients participating in the study. Higher positive FAST percentage but percentage of solid organ injury (0.5%) was lower than CT (2.5%).

In our study, 88.1% (516) of the patients were at very low risk according to the four-variable clinical prediction rule. In very low-risk patients for intraabdominal injury, the abnormal CT rate was 0.3% (spleen contusion $n=1$). With the use of four variables, 0.17% of solid organ injury may be overlooked. 97.1% of the patients were observed in the emergency service, 2.9% were hospitalized in the pediatric surgery service, and conservative treatment was performed.

In this study, 11.9% (70) of the patients were considered at risk for intra-abdominal injury. 2.9% of these patients were abnormal CT findings. 54.2% of the patients were admitted to the emergency service observation, 14.2% to intensive care, and 31% to pediatric surgery. While tube thoracostomy was performed in four patients with pneumothorax, conservative treatment was performed in other patients. The mean duration of stay in the intensive care unit was 1.4 ± 0.5 days (1–2 days), and the average length of stay in the ward was 4.6 ± 1.1 days (3–7 days) (Table 1).

The sensitivity was 97.3%, specificity was 98.2%, and accuracy was 97.4% in very low-risk patients with four variables of clinical prediction rule. In patients with intra-abdominal injury, the sensitivity was 90.3%, specificity 93.7%, and accuracy was 90.2% (Table 2).

The cost of each patient who was considered to be at very low risk for intra-abdominal injury and underwent a CT scan was 291.5 TL, and the cost of a patient considered to be very low risk and without CT was 53 TL. It was determined that routine CT scan increased the patient's cost 5.5 times (Table 3).

Discussion

Many factors from delayed diagnosis to morbidity, mortality, malpractice anxiety, and hospital cost play a role in the management of patients with blunt trauma. CT is preferred for quick detection and grading of toraco-abdominal, skeleton, and neurological injury in high-energy trauma [15]. However, it is difficult to distinguish between which patients CT is necessary and between which it is unnecessary. No pathological finding is observed in 74% of CTs performed in patients with blunt trauma [5]. In the study of Streck et al., it was reported that approximately 15% of patients with blunt trauma had intra-abdominal injuries and that non-operative treatment was generally sufficient [1]. In our study, 83.8% of

Table 1 According to risk groups, the demographic, and radiological data of the patients

	Patients with very low risk ***n*** **= 516** ***n*** **(%)**	**Patients with risk** ***n*** **= 70** ***n*** **(%)**	**Total 586** ***n*** **(%)**
Mean age (years)	10.1 ± 4.7	10.1 ± 4.5	10.2 ± 3.7
Gender			
Female	191 (37.1)	19 (27.1)	210 (35.8)
Male	325 (62.9)	51 (72.9)	376 (64.2)
Trauma mechanism			
Falling from height	351 (68.1)	45 (64.3)	396 (67.5)
Motor vehicle accident	122 (23.6)	14 (20)	136 (23.2)
Falling objects	27 (5.2)	6 (8.5)	33 (5.6)
Motor vehicle crash	16 (3.1)	5 (7.1)	21 (3.6)
CXR			
Pneumothorax		2 (2.8)	2 (0.3)
Pneumothorax+clavicula fracture		3 (4.3)	3 (0.5)
Lung contusion		2 (2.8)	2 (0.3)
Abdominal CT			
Spleen	1 (0.2)	6 (8.6)	7 (1.2)
Liver		4 (5.7)	4 (0.7)
Kidney		4 (5.7)	4 (0.7)
Intraabdominal free fluid	1 (0.2)	3 (4.2)	4 (0.7)
FAST			
Kidney		2 (2.8)	2 (0.3)
Spleen		1 (1.4)	1 (0.2)
Intraabdominal free fluid	10 (1.9)	10 (14.2)	20 (3.4)

CXR chest x-ray, *CT* computed tomography, *FAST* focused assessment with sonography for trauma

Table 2 Performance of clinical decision rule

	Patients without IAI (95%CI)	Patients with IAI (95%CI)
Sensitivity	97.3% (95.6–98.5)	93.3% (68.1–99.8)
Specificity	98.2% (90.6–99.89)	90.1% (87.4–92.5)
Positive predictive value	99.8 (98.6–99.9)	20 (15.8–24.9)
Negative predictive value	80 (70.4–87.1)	99.8 (98.7–99.9)
Negative likelihood ratio	0.03 (0.02–0.05)	0.07 (0.01–0.4)
Accuracy	97.4 (95.8–98.5)	90.2 (87.5–92.5)

IAI intraabdominal injury

Table 3 The hospital cost of each patients

Outcome	Total cost (TL)
Patient with IAI, abnormal CT, and admitted to hospital	563.48
Patient with IAI, abnormal CT, and observation in the emergency service	366.16
Patient without IAI, normal CT, and discharge	291.51
Patient without IAI, not receiving CT, and discharge	53

IAI intraabdominal injury, *CT* computed tomography

abdominal CT performed with suspicion of intra-abdominal injury were normal. In our study, 2.5% intra-abdominal injury was detected. It was thought that the reason for the low rate of intra-abdominal injury in our study might be related to the fact that this study was performed in the general emergency service, not in the trauma center, unlike other studies.

In the study conducted by Streck et al., a clinical prediction rule containing five variables (abdominal pain, abnormal physical examination findings, abnormal CXR, AST > 200 IU/L, and amylase) was defined and it was emphasized that the application of this clinical prediction rule could help the emergency physician to make a CT scan decision in the evaluation of blunt trauma patients [8]. It has been reported that the intra-abdominal injury risk of the patients was determined in a short time and that CT was not required in the first evaluation in one third of the patients [8]. In another study, it was observed that the sensitivity of the five-variable clinical prediction rule in determining the risk of intra-abdominal injury was 97.5% and intra-abdominal injury was missed by 0.7% [10]. With the application of clinical prediction rule consisting of history and physical examination, 0.5% intra-abdominal injury was missed, CT scan decreased 23.2%, and hospital cost was reduced by 50% [6]. In the emergency department of our hospital, if the quaternary variable consisting of abdominal pain, abnormal physical examination finding, CXR, and AST > 200 IU/L is applied, the intra-abdominal injury may not be detected in only 0.17% of children with blunt trauma. The results of our study showed that the four-variable clinical prediction rule had a higher sensitivity and accuracy rate in identifying patients with a very low risk of intra-abdominal injury than patients with intra-abdominal organ injury. According to the four-variable clinical prediction rule, very low-risk patients do not require immediate CT. In very low-risk patients, we recommend 12–24 h of observation to avoid missing injuries. If we had applied the clinical prediction rule when evaluating patients, the number of CT scan would have been reduced by 50.5% and the hospital cost would have been reduced by 23.6%. The findings obtained in this study suggest that the application of the four-variable clinical prediction rule could reduce CT imaging and prevent unnecessary radiation exposure of the patients.

History and physical examination have an important role in the management of patients with blunt trauma [1, 7, 16, 17]. Holmes et al. reported that 0.1% of blunt trauma patients were abducted, CT scan was reported to decrease 23% by clinical decision rule including abdominal wall trauma symptom, Glasgow Coma Scale (GKS) score > 13, abdominal tenderness, thoracic wall trauma, abdominal pain, decreased respiratory noise, and vomiting [6]. Patients with abdominal pain, signs of peritoneal irritation, and abdominal wall trauma have a high risk of intra-abdominal injury [6, 9]. In our study, abdominal pain, abdominal guarding, and signs of trauma in the abdominal wall were associated with intra-abdominal organ injury, and it supported no need for urgent CT scans in patients without these findings.

Clinical prediction rules including laboratory tests such as pancreatic enzymes and hepatic transaminases have been used to detect intra-abdominal injury in patients with blunt trauma [9, 11, 16]. It was thought that increased AST increased the sensitivity of the clinical prediction rule [14], and an AST > 200 IU/L could be an indication for a CT scan [18]. In the study of Streck et al., it was stated that AST reflects potential liver damage or ischemia, which was high in 68.8% of patients with intra-abdominal injury [1]. In patients with blunt trauma, the elevation of AST or ALT alone does not diagnose liver injury. AST, ALT, examination, and hemodynamic status should be evaluated together [18]. In our

study, 40% of patients with intra-abdominal injuries had AST > 200 IU/L. The results of our study suggest that patients with AST ≤ 200 U/L can be evaluated together with history and examination instead of emergency CT.

Routine CXR in patients with trauma is significant for parenchymal evaluation and detecting rib fractures that may occur in proportion to the severity of trauma [19]. It has been recommended that patients with rib fractures should be evaluated with further examination [20]. Patients with pathology on CXR have low GCS, and CT indication cannot be made only with low GCS [21]. Our study supports that although pneumothorax, lung contusion, and rib fracture, if other examination and laboratory findings are normal, immediate abdominal CT is not required, and close follow-up is required.

Limitations

The limitations of our study are as follows: a single-center, retrospective, general emergency service where pediatric and adult patients were evaluated together. There is a need for prospective and multi-center studies to be conducted in a pediatric trauma center.

Conclusions

Patients with very low intra-abdominal injury risk exposed to blunt trauma can be identified with a four-variable clinical prediction rule. According to the four-variable clinical prediction rule, very low-risk patients do not require immediate CT. The hospital costs can be reduced by reducing the CT scan. However, it should be kept in mind that a low rate of intra-abdominal injuries may be overlooked by applying a four-variable clinical prediction rule.

Abbreviations

CT: Computed tomography; FAST: Focused Assessment with Sonography for Trauma; AST: Aspartate aminotransferase; CXR: Chest X-ray; GKS: Glasgow Coma Scale; NPV: Negative predictive values; PPV: Positive predictive values.

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Not applicable.

Authors' contributions

T.Ö., S.A., and SB contributed to the literature search and the study design; T.Ö., S.A., and SB contributed to the data collection, statistical data analysis, and data interpretation and the drafting manuscript and approved the final version. The authors have read and approved the manuscript.

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Availability of data and materials

The datasets (SPSS files) used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The study was approved by the Clinical Studies Ethics Committee of Health Sciences University (08.03.2019/number: 238). Since the study was of a retrospective nature, informed consent was not obtained from the participants. However, written informed consent was obtained from the parents of the patients for the examinations and treatments to be performed upon arrival at the hospital.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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