Paediatric Emergency Care; Applied Research Network Prediction Rule for Early Detection of Intra-Abdominal Injuries in Children

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ABSTRACT
Background: Blunt abdominal trauma is the third most common cause of pediatric trauma deaths, but it is the most common unrecognized fatal injury.
Objective: Our study aimed to assess the Pediatric Emergency Care Applied Research Network (PECARN) score rule regarding early prediction of intra-abdominal injuries in children with blunt abdominal trauma in order to improve their outcome and reduce percentage of missed abdominal injuries.
Methods: A cross-sectional observational study included 123 children presented to Emergency Department in Suez Canal University Hospital, Ismailia with blunt abdominal trauma within 24 hours. All the patients included in the study were subjected to full history, data of trauma, clinical examination and routine laboratory and radiological investigations.
Results: The mean age of our study participants was 9.49 ± 4.379 years. The majority of participants (65.0%) were males. Regarding CT with IV contrast, it was found to be abnormal in 62 children (50.4%). PECARN is statistically significantly positively correlated with organ injury (V= 0.532) (p < 0.001). PECARN clinical prediction showed significant area under curve of 0.945 with maximum sensitivity of 80.6% and specificity of 98.1% with accuracy of 88.7%.
Conclusion: Pediatric emergency care applied research network prediction score (PECARN) had a valuable role in prediction of intra-abdominal injuries in children with blunt abdominal trauma (BAT).
Keywords: Paediatric Emergency Care Applied Research Network Prediction Rule, Intra-abdominal injuries, Children.

INTRODUCTION

Injuries are a prominent factor contributing to mortality and impairment in children and adolescents below the age of eighteen. Abdominal trauma caused by motor vehicle crashes (MVC), falls and sports-related injuries, or other factors can lead to substantial mortality due to injuries to solid organs or hollow viscera [1].

The optimal evaluation technique for ascertaining intra-abdominal injury (IAI) remains a subject of ongoing discussion, despite the frequent occurrence of pediatric abdominal trauma [2].

Adolescents are more susceptible than adults to blunt trauma. Due to their smaller body size, children can experience several traumatic injuries in various locations, as their traumas can spread over a broader area. Children with a smaller torso, larger and more mobile internal organs, and less fat inside the abdomen are at a higher risk of experiencing injury to their internal organs [3].

Blunt abdominal trauma in children is the result of various frequent mechanisms. Motor vehicle collisions (MVC) are the main factor contributing to abdominal trauma in children, making up more than 50% of reported occurrences. Ecchymosis, abrasions, lacerations, abdominal discomfort, or distention are physical examination findings commonly observed in cases of blunt trauma. The spleen and liver are the solid organs that are most frequently harmed. A worrying and sometimes unnoticed finding is the presence of the "seat belt sign," which results from abrasions or ecchymosis induced by the use of restraining belts. If the belt

markings are not positioned over the bony pelvis, there is a risk of significant injury. The belt's shoulder component may be positioned at an abnormally low level, or its lap section may be positioned at an excessively high level, resulting in the occurrence of injuries. People who use seat belts are at a higher risk of experiencing intraabdominal injuries, particularly to the hollow viscus [4]. Blunt abdominal trauma refers to any impact that damages the abdominal cavity, regardless of where it occurs, without causing a break in the abdominal wall [5].

Intra-abdominal injury (IAI) is a medical and surgical emergency where vital and functional prognoses are involved. The primary cause of these occurrences is predominantly automobile accidents, constituting around 80% of all instances of abdominal trauma [5].

Hence, our study aims to assess the effectiveness of the Pediatric Emergency Care Applied Research Network (PECARN) score rule in predicting intra-abdominal injuries at an early stage. The objective was to reduce the incidence of overlooked abdominal injuries and enhance the prognosis of children with blunt abdominal trauma through early identification of intra-abdominal injuries.

MATERIAL AND METHODS

A cross-sectional observational study was conducted, involving a total of 123 children aged between 2 and 18 years old. Patients arrived at the Emergency Department of Suez Canal University

Hospital in Ismailia with non-penetrating injuries to the abdomen within a 24-hours period.

Exclusion criteria: Patients who suffered severe head or chest traumas, fractures in their extremities or pelvis, penetrating injuries, chronic debilitating conditions and patients who had been referred from another hospital after undergoing any surgical or medicinal intervention.

All patients enrolled in the study underwent a comprehensive evaluation including a thorough medical history, trauma data, clinical examination, routine laboratory tests, and radiological investigations. Additionally, the Pediatric Emergency Care Applied Research Network (PECARN) score was applied to all patients upon their arrival at our department.

The PECARN's clinical prediction rule for blunt abdominal trauma [6]:

The purpose of this was to identify children who had an extremely low likelihood of experiencing a clinically significant injury within the abdomen.

There were seven requirements specified in the rule:
- o No evidence of abdominal wall trauma or seat belt sign.
- o GCS score greater than 13.
- o No abdominal tenderness.
- o No evidence of thoracic wall trauma.
- o No complaints of abdominal pain.
- o No decreased breath sounds.
- o No vomiting.

- If the patient hadn't any of the seven criteria, he/she was at risk of intra-abdominal injuries.

Then, the patients had been divided into 2 groups: proven to have IAI by CT or laparotomy and non-proven to have IAI injury by CT or laparotomy. Patients were managed by therapeutic laparotomy, blood or blood product transfusion and IV fluid administration The patients had been followed up and recorded till one of the following outcomes was reached:
- • Discharged home
- • Admitted to inpatient ward
- • Admitted to ICU
- • Had surgical intervention
- • Mortality

Ethical approval: The Ethics Committee of Faculty of Medicine, Suez Canal University approved this study. The participants enrolled in this study provided written informed consents to partake in this investigation. Written informed consent was obtained from the patients for publication of this study and accompanying images. The Helsinki Declaration was adhered to at every stage of the investigation.

Statistical analysis

All analyses were performed using statistical package for social sciences (SPSS) for windows version 22.0 (SPSS, Chicago, IL, USA). Descriptive data were presented as mean ± SD or percentages. Fisher's exact test and Chi-square test were used for statistical analysis of categorical variables as appropriate. Analysis of continuous variables was performed by independent t-test or non-parametric Mann-Whitney U-test according to the normality of the distributions. For all tests, a probability value ≤ 0.05 was considered statistically significant.

RESULTS

The mean age of our study participants was 9.49 ± 4.379 years, 45.5% were aged 6 – 12 years, 30.9% were more than 12 years, and 23.6% were < 6 years. The majority of participants (65.0%) were males (Table 1).

Table 1: Baseline data of the studied patients

All patients (n= 123)		Mean & SD	Median	Range	IQR
Age (years)		9.49 ± 4.379	9.00	3.00, 17.00	6.00, 13.00
Age	**> 2 – < 6 years**	29 (23.6%)			
	6 – 12 years	56 (45.5%)			
	> 12 – < 18 years	38 (30.9%)			
Gender	**Males**	80 (65.0%)			
	Females	43 (35.0%)			
Residency	**Rural**	68 (55.3%)			
	Urban	55 (44.7%)			

Figure (1) illustrated the mechanism of trauma, it was found that in about 50.4% of the patients, the mechanism of trauma was road traffic accidents, in 27.6% it was fall from height, in 17.9% it was direct trauma, in 2.4% was quarrel and in 2 (1.6%) it was sliding.
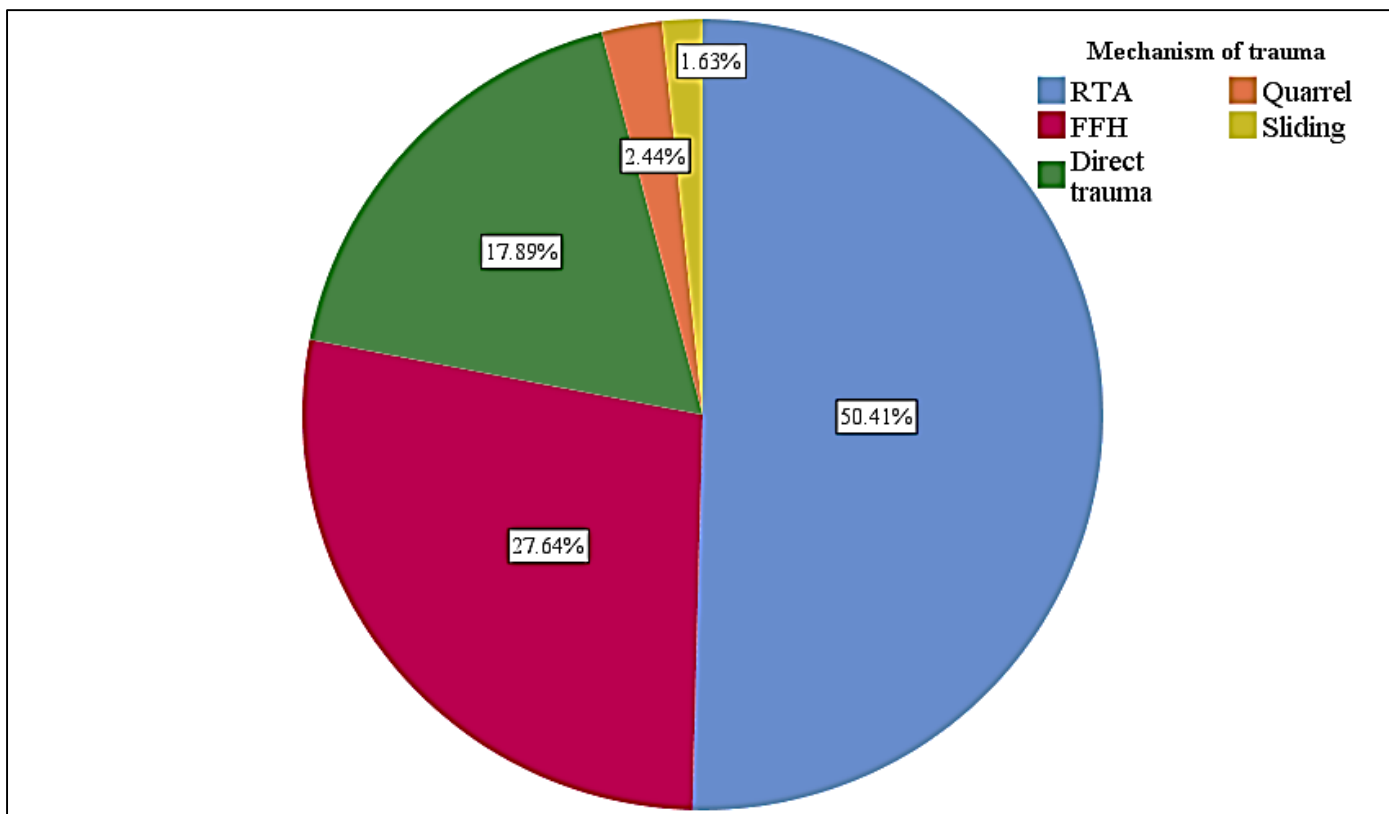

Figure (1): Trauma characteristics of the studied sample.

Table (2) showed the presence of organ injury and organ injuries discovered by CT showed that slightly more than half 62 (50.4%) of patients had organ injury, while 53 (43.1%) were free from any organ injury, and assessment was not done in 8 (6.5%) of patients. Among the 62 patients who had organ injury, the most common injured organ was liver in 37 (59.7%), followed by spleen in 15 (24.2%), pancreas in 8 (12.9%), then kidney and stomach equally in 1 (1.6%).

Table (2): Presence of organ injury and Organ injured of the studied sample

All patients (n= 123)		Frequency	Percentage
Presence of organ injuries discovered by CT with contrast	**Absent**	53	43.1%
	Present	62	50.4%
	Not done	8	6.5%
Organ injured	**Spleen**	15	24.2%
	Liver	37	59.7%
	Kidney	1	1.6%
	Stomach	1	1.6%
	Pancreas	8	12.9%

Table (3) showed that according to the PECARN Clinician prediction rule, abdominal wall trauma/Seat belt sign was found in 55 (44.7%) of patients, abdominal tenderness in 77 (62.6%), thoracic wall trauma in 4 (3.3%), abdominal pain in 79 (64.2%), decreased breath sounds in 4 (3.3.%), vomiting in 28 (22.8%), and high risk in 95 (77.2%).

Table (3): PECARN Clinician prediction rule of the studied sample

All patients (n= 123)	Frequency	Percentage
Abdominal wall trauma / Seat belt sign	55	44.7%
Abdominal tenderness	77	62.6%
Thoracic wall trauma	4	3.3%
Abdominal pain	79	64.2%
Decreased breath sounds	4	3.3%
Vomiting	28	22.8%
High risk	95	77.2%

Table (4) demonstrated the outcome of the studied sample where the most common outcome was discharge in 42 (34.1%) of patients, followed by laparotomy in 35 (28.5%), ICU admission in 20 (16.3%), conservative

inpatient in 18 (14.6%) and death in 8 (6.5%) of patients.

Table (4): Outcome of the studied sample

All patients (n= 123)	Frequency	Percentage
Discharge	42	34.1%
Laparotomy	35	28.5%
Conservative Inpatient	18	14.6%
ICU Admission	20	16.3%
Died	8	6.5%

Regarding, the PECARN clinician prediction rule out of 123 children, 28 children were classified as low risk predicted; 26 (49.1%) of patients with no IAI and the rule failed to identify 2 (2.9%) of patients with IAI. While, for high-risk patients, 68 (97.1%) of them had IAI and 27 (50.9%) of them had no IAI, with statistically significant difference between PECARN clinician prediction rule and the presence of organ injury (p < 0.001) (table 5) and with statistically significantly positively correlated with organ injury (r= 0. 532) (p < 0.001) (table 6).

Table (5): BATic score according to presence of organ injury in the studied sample

All patients (n= 123)		No IAI (n= 53)	IAI (n= 70)	P
PECARN (frequency & percentage)	**Low Risk**	26 (49.1%)	2 (2.9%)	**< 0.001**
	High Risk	27 (50.9%)	68 (97.1%)	

Table (6): Correlation between BATic score with presence of organ injury in the studied sample

	Organ injury	P
PECARN (Cramer's V coefficient)	0.532	**< 0.001**

Data is expressed as mean and standard deviation or as percentage and frequency. P is significant when < 0.05.

Figure (2) & table (7) showed ROC curves that were used to estimate the diagnostic profile of PECARN score positive components in detecting abdominal organ injury. ROC curve was also used to estimate the diagnostic profile of PECARN clinical prediction rule in detecting abdominal organ injury. When PECARN clinical prediction rule had 3 positive criteria it showed significant area under curve of 0.945 with maximum sensitivity of 80.6% and specificity of 98.1% with accuracy of 88.7%.

Table (7): Diagnostic profile of BATic score in detecting abdominal organ injury

	BATic score
AUC	0.945
95% CI of ACU	0.896, 0.993
P	**< 0.001**
Cutoff point	3
Youden's index	0.787
Sensitivity	80.6%
Specificity	98.1%
PPV	98.0%
NPV	81.3%
Accuracy	88.7%
P is significant when < 0.05.	

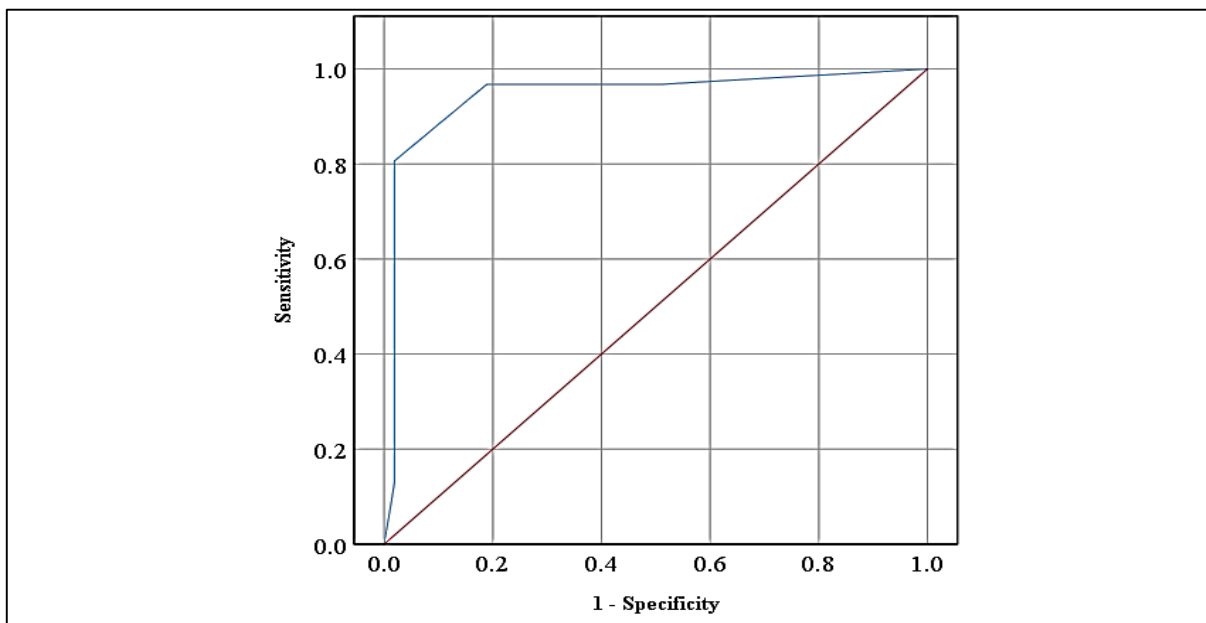

Figure (2): Roc curve for diagnostic profile of PECARN score positive components for diagnosis of abdominal organ injury

DISCUSSION

Diagnosing intra-abdominal injuries (IAI) can be challenging, and abdominal trauma continues to be a significant cause of illness and death in children. The abdominopelvic computed tomography (CT) scan is currently considered the most reliable method for assessing intra-abdominal infections (IAI) in both young and adult individuals. More than 50% of abdominopelvic CT scans performed on children with severe abdominal injuries are likely to be unnecessary, and in more than 90% of cases, a CT scan does not significantly impact the treatment decision [7-9]. The main objective of this study was to assess the effectiveness of the Pediatric Emergency Care Applied Research Network (PECARN) scoring rule in predicting early intra-abdominal injuries to reduce the rate of undetected abdominal injuries and enhance the prognosis of children with traumatic abdominal trauma.

This study included 123 participants, with an average age of 9.49 ± 4.379 years, ranging from over 2 to under 18 years. Out of the total, 80 individuals, accounting for 65.0% of the sample, were males. The level of physical activity among boys in our community surpasses that of females, resulting in their heightened vulnerability to experience traumatic events.

According to **Khirallaha et al.** [10] during a span of two years, a total of 250 children sought medical attention at their institute's emergency room because to BAT, which aligns with our research results. The age of the patients varied between 2 and 18 years, with an average age of 10.14 years. Out of the patients included in the study conducted by **Anıl et al.** [11], 143 individuals, accounting for 67.1% of the total, were males.

Regarding the mechanism of trauma, it was found that road traffic accidents accounted for 50.4% of cases, falls from height accounted for 27.6%, direct trauma accounted for 2.4%, arguments accounted for 1.6%, and slides accounted for 1.6%. The proliferation of road networks and the corresponding increase in road transportation, along with a disregard for safety regulations and a lack of adherence to traffic rules, collectively contribute to the high incidence of road traffic accidents (RTAs). This can also be elucidated by youngsters engaging in unsupervised play without the presence of adults. Similar findings were reported by **Djordjevic et al.** [12] who found that vehicle accidents were responsible for 64.5% of all injuries. Falls from a height were the second most common cause, accounting for 22.5% of injuries. Bicycle handlebar injuries, contact sports, and child maltreatment each accounted for 6.45% and 3.22% of injuries, respectively. According to **Arbra et al.** [8],

The majority of occurrences of blunt abdominal trauma in children (34.5%) were caused by car incidents, followed by falls from height (25.4%) and pedestrians or cyclists (18.9%). Nonetheless, **Sigal et al.** [13] in their study revealed that falls accounted for 52%

of traumatic abdominal injuries in children, whereas car incidents were responsible for 40.8% of such injuries.

Out of the 73 patients who received CT scans with intravenous contrast, it was determined that 62 of them had intra-abdominal infections (IAI). The discrepancy was explained by the presence of rims and inadequate FAST collection in 11 individuals. Furthermore, CT scans with contrast, conducted following the administration of intravenous contrast, did not detect any intra-abdominal damage.

Out of the total of 50 instances, which accounted for 40.7% of the sample, the CT scan of the abdomen and pelvis was not conducted. In 42 cases, the children did not exhibit any indications of IPFF as determined by FAST, or they were immediately taken to the operating room (OR) due to unstable hemodynamics.

Regarding the occurrence of organ injury, the present study found that 70 patients had IAI, with 62 (50.4%) of them having organ injury detected by CT. Among these, 8 patients were immediately taken to the operating room and died before undergoing CT. Additionally, 43.1% of patients had no organ injury. The liver was the organ most frequently afflicted among the patients, with a prevalence of 59.7%. The spleen followed with a prevalence of 24.2%, while the pancreas had a prevalence of 12.9%. The kidney and stomach were impacted similarly, each with a prevalence of 1.6%.

The study of **Arbra et al.** [8] who aimed to verify a 5-Variable Clinical Prediction Rule for identifying children at a very low risk of intra-abdominal injury following blunt abdominal trauma, aligns with our research results. A total of 235 patients, accounting for 9.7% of the 2,435 persons included in the study, were diagnosed with IAI either in the emergency department or during their initial hospitalization. The liver was reported as the most often injured organ, accounting for 40.9% of cases. The spleen followed closely behind with 39.6% of reported injuries. The kidney accounted for 18.7% of injuries, while the small bowel, mesentery, and large bowel accounted for 12.3%, 7.2%, and 6.4% of reported injuries respectively.

The study of **Streck et al.** [7] aimed to create a prediction algorithm that can accurately identify children who are highly unlikely to acquire intra-abdominal injuries after experiencing blunt abdominal trauma (BAT). After conducting BAT, a total of 2,188 children were enrolled in the experiment. Among them, 261 patients (11.9%) had IAI-I. The study indicated that liver injuries were the most common, with spleen damage being the second most frequent.

According to the PECARN Clinician Prediction Rule, 55 patients (44.7%) experienced abdominal wall trauma or the Seat Belt Sign. Additionally, 77 patients (62.6%) had abdominal soreness, 4 patients (3.3%) had thoracic wall damage, 79 patients (64.2%) had

abdominal pain, 4 patients (3.3%) had diminished breath sounds, and 28 patients (22.8%) experienced vomiting. Also, the sample under research yielded the following results: Patient release was the most frequent outcome accounting for 34.1% of cases followed by laparotomy at 28.5%, ICU hospitalization at 16.3%, conservative inpatient care at 14.6%, and patient death at 6.5%. **Anil et al.** [11] Encompassed a total of 105 patients that were admitted to the hospital. Out of the total number of patients, 73 (69.5%) were admitted to the general ward, while 25 (23.80%) were admitted to the Pediatric Intensive Care Unit (PICU), according to the disposition type recorded at the Pediatric Emergency Department (PED). Seven patients were directly transferred from the Emergency Department to the operating room.

Out of the 123 children included in our study, 28 were classified as low risk based on the PECARN clinician prediction criterion, and two of them were found to have intra-abdominal injuries (IAI). Among the high-risk group, 27 patients (50.9%) did not have intra-abdominal injury (IAI), while 68 patients (97.1%) did have IAI. There was a significant statistical difference (p ~ 0.001) between the presence of organ injury and the PECARN clinician prediction criteria. There was a strong and significant positive relationship between organ damage and PECARN, with a correlation coefficient (V) of 0.532 and a p-value of less than 0.001. **Sigal et al.** [13] study revealed a significant association between PECARN and organ harm that align with the findings of the current analysis.

The ROC curve was used to determine the diagnostic profile of the PECARN clinical prediction rule for diagnosing abdominal organ injury. When the clinical prediction rule satisfied three positive conditions, it exhibited a substantial area under the curve of 0.945, with a maximum sensitivity of 80.6%, specificity of 98.1%, and accuracy of 88.7%.

Springer et al. [6] conducted a retrospective single-center external validation study using their pediatric trauma registry. The purpose of the study was to confirm the accuracy of the PECARN prediction rule in identifying patients who have an extremely low risk of clinically significant intra-abdominal injuries (CIIAI). According to their statement, the rule had a sensitivity of 99% for identifying IAI cases that required prompt care. Data provide evidence in favor of using the PECARN clinical prediction criteria to decrease the utilization of CT scans in pediatric patients who have a very low risk of developing complications from contrast-induced acute kidney injury (CIIAI). According to **Holmes et al.** [14], when applied the PECARN clinical prediction criteria to identify children with any intra-abdominal injury (IAI) that required intervention in patients at extremely low risk, the PECARN criteria demonstrated a sensitivity of 97% and specificity of 42%. The test characteristics obtained, despite the rule being developed to identify low-risk

patients undergoing acute intervention for intra-abdominal injury, were as follows: Sensitivity of 92.5%, specificity of 44.1%, positive predictive value of 10.0%, and negative predictive value of 98.9%. Additionally, they assessed the efficacy of the criterion in detecting children with any intra-abdominal damage, regardless of whether they received medical attention or not. In addition to lab and chest x-ray data, **Streck et al.** [15] created a prediction approach that is based on readily available historical and physical examination information. The prediction rule for identifying IAI and determining the need for intervention had a sensitivity of 98.4% and 100% respectively. The rule, however, relies on the presence of prompt laboratory results, which may not be accessible at all facilities, and has a lower level of specificity (38% and 34.7%) compared to the PECARN study.

CONCLUSION

The Pediatric Emergency Care Applied Research Network Prediction Score (PECARN) plays a crucial role in predicting intra-abdominal injuries in children who have experienced blunt abdominal trauma (BAT).

RECOMMENDATION

Additional research involving a greater number of participants and multiple research centers is necessary to validate the current findings.

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