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 (3).

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 intra-abdominal 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**

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:
- No evidence of abdominal wall trauma or seat belt sign.
- GCS score greater than 13.
- No abdominal tenderness.
- No evidence of thoracic wall trauma.
- No complaints of abdominal pain.
- No decreased breath sounds.
- 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**

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

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 (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 (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

<table>
<thead>
<tr>
<th>All patients (n=123)</th>
<th>Frequency</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge</td>
<td>42</td>
<td>34.1%</td>
</tr>
<tr>
<td>Laparotomy</td>
<td>35</td>
<td>28.5%</td>
</tr>
<tr>
<td>Conservative Inpatient</td>
<td>18</td>
<td>14.6%</td>
</tr>
<tr>
<td>ICU Admission</td>
<td>20</td>
<td>16.3%</td>
</tr>
<tr>
<td>Died</td>
<td>8</td>
<td>6.5%</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>All patients (n=123)</th>
<th>No IAI (n=53)</th>
<th>IAI (n=70)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PECARN (frequency &amp; percentage)</td>
<td>Low Risk</td>
<td>26 (49.1%)</td>
<td>2 (2.9%)</td>
</tr>
<tr>
<td></td>
<td>High Risk</td>
<td>27 (50.9%)</td>
<td>68 (97.1%)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Organ injury</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>PECARN (Cramer’s V coefficient)</td>
<td>0.532 &lt; 0.001</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>BATic score</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>PPV</th>
<th>NPV</th>
<th>Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUC</td>
<td>0.945</td>
<td>98.0%</td>
<td>98.1%</td>
<td>81.3%</td>
<td>88.7%</td>
</tr>
<tr>
<td>95% CI of ACU</td>
<td>0.896, 0.993</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cutoff point</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Youden’s index</td>
<td>0.787</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>80.6%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specificity</td>
<td>98.1%</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>PPV</td>
<td>98.0%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>NPV</td>
<td>81.3%</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Accuracy</td>
<td>88.7%</td>
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</tbody>
</table>

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 Khirallah 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 Anil 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 (23.8%) 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 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, Streek 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.

- **Funding:** This publication did not receive any financial support.
- **Availability of data and materials:** The data that substantiate the conclusions of this study can be obtained by contacting the relevant author upon request.
- **Competing interests:** The authors declared that they had no competing interests.

REFERENCES


