Original Article

Accuracy of Pediatric Emergency Care Applied Research Network Rules in Predicting Brain Injuries

Fereshteh Jamali, Sepideh Gholizadeh, Mahsa Kangari, Amir Ghaffarzad, Haniyeh Ebrahimi Bakhtavar, Farzad Rahmani[1]

Emergency and Trauma Research Center, Tabriz University of Medical Sciences, [1]Road Traffic Injury Research Center, Tabriz University of Medical Sciences, Tabriz, IR Iran

ORCID

Fereshteh Jamali: https://orcid.org/0000-0002-2385-2439
Sepideh Gholizadeh: https://orcid.org/0000-0001-9102-8508
Mahsa Kangari: https://orcid.org/0000-0002-9569-9429
Amir Ghaffarzad: https://orcid.org/0000-0002-5070-2583
Haniyeh Ebrahimi Bakhtavar: https://orcid.org/0000-0002-8696-7321
Farzad Rahmani: https://orcid.org/0000-0001-5582-9156

Abstract

Background and Objectives: Head trauma is one of the most important causes of emergency department (ED) visits and the leading cause of disability and mortality in children. The aim of this study was to evaluate the Pediatric Emergency Care Applied Research Network (PECARN) rules to predict brain injuries in pediatrics with head trauma. **Materials and Methods:** This descriptive–analytic study was performed on 250 pediatric patients with head trauma referred to Imam Reza Hospital in Tabriz City from August to September 2020. All patients were evaluated in the ED for the existing of any rules of the PECARN, then the results of the PECARN rules and brain computed tomography (CT) scan findings were compared in these patients. According to the PECARN rules, patients were classified into three categories, namely low, moderate, and high risk. For all three groups, if there is an indication of brain CT scan, it was performed and reported by an emergency medicine specialist. **Results:** The mean age of the patients was 88 months. In this study, 162 (64.8%), 42 (16.8%), and 46 (18.4%) patients were in the low-risk, moderate-risk, and high-risk groups, respectively. Death was occurred in 18 (12.8%) patients. Results showed a statistically significant association between positive CT findings and some variables, such as behavioral change, vomiting, severe headache, LOC over 5 s, confusion, palpable skull fracture, skull base fracture, and the severe mechanism of injury ($P < 0.05$). Furthermore, a statistically significant association was found between PECARN rules and CT findings ($P < 0.001$). **Conclusions:** According to the results of the present study, PECARN rules have a significant association with brain CT scan findings. Therefore, using these rules is recommended to reduce the number of brain CT scan requests for pediatric patients.

Keywords: Brain trauma, child, decision support techniques, emergency service, hospital, tomography, X-ray computed tomography

Introduction

Head trauma is one of the most important causes of emergency department (ED) visits and is the leading cause of disability and mortality in children.[1-4] Falling from height, car accidents, and child abuse are the main causes of head trauma in children.[1,5] Head trauma is among one of the prevalent acute events in children in Iran with an increasing rate.[6]

Head computed tomography (CT) is needed to evaluate head trauma severity based on the patients' symptoms.[1,2,4] X-ray exposure in CT is associated with an increased incidence of malignancies. In children with multiple CT scans in the first 15 years, an increased risk of leukemia and brain tumors is reported.[7] It was reported that for every 10,000 CT in children less than 10 years, one leukemia and one case of a brain

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Address for correspondence: Prof. Farzad Rahmani, Department of Emergency Medicine, Faculty of Medicine, Tabriz University of Medical Sciences, Golgasht Avenue, Tabriz, Iran.
E-mail: Rahmanif@tbzmed.ac.ir

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tumor would occur in the next 10 years after CT.[1,2] Delay in diagnosis and treatment of brain injuries in children will cause an increased mortality rate and have a poor prognosis.[1,8]

However, improper use of head CT in the setting of head trauma is seen because of some reasons, including lack of physician confidence in his/her clinical ability to diagnose, psychological and verbal pressure of the child's parents to do the imaging, limitation of verbal communication with the child, difficulties in neurologic examinations and lack of a uniform strategy for imaging in hospitals, and the most important of all lack of an appropriate alternative method.[2] Pediatric Emergency Care Applied Research Network (PECARN) in 2009 introduced scoring tools and methods to identify children with low-risk trauma to prevent improper imaging. The children were classified into three categories based on the PECARN rules: low, intermediate, and high risk [Table 1]. Positive PECARN is determined by the presence of at least one item in the high- or intermediate-risk category.[8] Since the studies showed controversial results about the application of the PECARN rules in the setting of head trauma in children, this cross-sectional descriptive study was performed to investigate the diagnostic value of this method.

Materials and Methods

This descriptive cross-sectional study was conducted on 250 pediatric brain trauma patients referred to Imam Reza Hospital in Tabriz City from August to September 2020. The inclusion criteria included children <18 years and head trauma in recent 24 h. Our exclusion criteria included nonsignificant trauma such as falling or hitting a sedentary body with no sign or with maximum damage to the scalp, penetrating trauma, confirmed brain tumor, history of previous neurologic deficits, which can lead to disruption in data analysis, brain imaging before referring to the hospital, the presence of ventricular shunt, hemorrhagic disorders, and parental dissatisfaction.

Demographic data as well as medical history were recorded using a checklist by the medical staff present in the ED without knowledge of the imaging results. These data included age (in the month), gender, Glasgow Coma Scale (GCS), change in consciousness, palpable skull fracture, signs of skull base fracture, severe mechanism of injury, loss of consciousness more than 5 s, nonfrontal hematoma, vomiting, and severe headache. Underlying diseases, history of drug use, mechanism of event, and treatment at the scene were considered confounding factors. Thus, stratification was used to control these factors. Brain CT scan (Siemens SOMATOM Emotion 6, Germany) was performed based on the indication in child head trauma, and reported by an emergency specialist.

Table 1: Classification of patients based on PECARN rules

Category	Under 2 years	Above 2 years
High risk	Mental status change Palpable skull fracture	Mental status change Symptoms of skull base fracture
Medium risk	Severe fracture mechanism Loss of consciousness more than 5 seconds Abnormal behavior of child in terms of parents Non-frontal hematoma	Severe fracture mechanism Loss of consciousness Severe headache Vomiting
Low risk	None of the above	None of the above

Head trauma with clinical significance is the main point in this study. Head trauma with clinical significance defines as head trauma that leads to death, neurosurgery, intubation for more than 24 h, and hospitalization for more than one night.[8] Results of PECARN rules and CT findings were compared in these traumas. Furthermore, the relationship between the severity of trauma based on GAP score[9,10] and PECARN rules was compared.

Finally, SPSS version 21 (IBM, Chicago, USA) was used for statistical analysis. To describe data, we used mean ± standard deviation (for quantitative variables) and frequency and percentage (for qualitative variables). Kolmogorov–Smirnov test was used to determine normal data distribution. For qualitative data analysis, the Chi-square test was used. Sensitivity, specificity, and positive and negative predictive values were also reported to determine the predictive value of PECARN rules in pediatric head trauma. $P < 0.05$ was considered statistically significant.

Ethical consideration

This study was approved by the Ethics Committee of Tabriz University of Medical Sciences, Tabriz, Iran. The approved ethical code was IR.TBZMED.REC.1399.645. Patients' information was preserved, and informed consent was obtained from the parents.

Results

The mean age of the patients was 88.12 months. From a total of 250 patients, 117 (46.8%) patients were female and 133 (53.2%) were male. In terms of vital signs, heart rate was 72.8 ± 14.18, systolic blood pressure was 93.3 ± 16.86, diastolic blood pressure was 56.96 ± 8.88, and O_2 saturation was 93.52 ± 6.49. GCS was 12.35 ± 3.19, and AP score was 19.64 ± 3.45. In this study, 75 (30%) children were under 24 months of age and 175 (70%) were above 24 months of age.

In terms of GAP severity, 178 (71.2%) patients were classified as mild, 70 (28%) as moderate, and 2 (0.8%) as severe. There is a significant statistical relationship between the GAP severity score and the PECARN rules ($P < 0.001$). Some of the important findings in patients are summarized in Table 2. During the evaluation of patients, 182 brain CT scans were performed, in which 80 (44%) cases had positive findings. Based on the PECARN rules, 162 (64.8%) patients were in the low-risk group, 42 (16.8%) patients were in the moderate-risk group, and 46 (18.4%) of them were in the high-risk group. Death was occurred in 18 (12.8%) patients. There was a

statistically significant association between positive CT findings and variables including behavioral change, vomiting, severe headache, LOC over 5 s, confusion, palpable skull fracture, skull base fracture, and the severe mechanism of injury ($P < 0.05$). As Table 3 shown, there was a statistically significant association between the PECARN rules and CT findings.

Tables 4 and 5 are used to determine the predictive value of the PECARN rules in two groups of patients (under 24 months and over 24 months of age). In patients < 24 months old, the sensitivity, specificity, positive predictive value, and negative predictive value of the PECARN rules were 0.91, 0.95, 0.89, and 0.96, respectively. In patients >24 months old, the sensitivity, specificity, positive predictive value, and negative predictive value of the PECARN rules were 1, 0.86, 0.78, and 1, respectively.

Discussion

Since the results are contradictory in terms of the application of the PECARN rules, this study was performed on 250 pediatric patients with a mean age of 88 months. In the present study, a total of 182 CT scans were performed among which 80 had positive results. Among all patients, 162 (64.8%) patients were in the low-risk group, 42 (16.8%) patients were in the moderate-risk group, and 46 (18.4%) of them were in the high-risk group. Death was occurred in 18 (12.8%) patients.

Previous studies have been shown that the application of the PECARN rules decreases the need for CT scans in the head trauma of children.[8] In a study performed by PECARN in 2009, a scoring method is presented to diagnose and identify the children with low-risk head trauma to prevent improper CT. This algorithm is approved in North America and Europe and is used to help decision-making in the head trauma setting.[8] However, this algorithm is not used in Asian countries yet. High sensitivity and specificity of this method are shown in a study conducted in Japan but this study was retrospective and it is recommended to do more studies.[1]

The results of a study conducted by Osmond *et al*. with the purpose of CT application in children with minor head trauma showed that the PECARN rule could identify children in two danger levels. Hence, this rule is approved prospectively. It has the potential to standardize and improve the use of CT for children with minor head injuries.[11] In a study conducted by Easter *et al*., on children with GCS of 13–15, the sensitivity of 100% and specificity of 62% were found in children with head trauma. These results were similar to our findings.[12] In another study by Pickering *et al*., on children with mild head trauma, PECARN rules had the highest sensitivity and specificity compared with other rules.[13]

In a study performed by Lorton *et al*., the sensitivity of 100% and specificity of 69% were found for the application of the PECARN rules in head trauma in children.[14] According to another study, the application of the PECARN rules can strengthen the physician's suspiciousness and prevent inappropriate use of CT scans in children with a low risk of head trauma.[15]

CT scans to detect brain injury in children with minor trauma can lead to radiation exposure and the effects of which usually manifest years later.[8] Sedation in children may be needed to perform certain procedures such as CT, which can lead to a long stay in the emergency room or unwanted complications.[16] The purpose of the PECARN rules is to reduce the number of unnecessary CT scans in pediatric brain trauma. The authors of the PECARN rules have developed an algorithm for performing CT scans in children with head trauma and GCS 14-15.[17] Research has shown that due to the importance of minor injuries in forensic medicine, the use of these rules in brain injury following abuse is not recommended and it is better to have a low CT scan threshold in these cases.[3] The results obtained in this study showed that the use of the PECARN rules in the ED is effective in reducing the number of CT scan requests in minor head trauma in children and there is a significant statistical difference between the results of performed CT scans and the results of the PECARN rules.

One of the limitations of the present study is the limitations of performing CT scans of children to enter the project. Lack of long-term follow-up of patients was another limitation of this study.

Table 2: Important positive findings of patients

Variables	Frequency (Percentage)
Intubation	42 (16.8%)
Behavioral changes	56 (22.4%)
Vomiting	47 (18.8%)
Severe headache	50 (20%)
LOC over 5 sec	44 (17.6%)
Confusion	52 (20.8%)
Palpable skull fracture	25 (10%)
Severe mechanism	58 (23.2%)
ICU admission	43 (17.2%)
Need for neurosurgery	58 (23.2%)

Table 3: Association between PECARN rules and brain CT findings

Age	CT finding	Low risk PECARN	Moderate risk PECARN	High risk PECARN	*P*
Above 2 years	Positive CT	5 (4.3%)	18 (78.3%)	32 (97%)	<0.001
	Negative CT	112 (95.7%)	5 (21.7%)	1 (3%)	
Under 2 years	Positive CT	0	13 (52%)	12 (48%)	<0.001
	Negative CT	45 (86.5%)	6 (11.5%)	1 (1.9%)	

Table 4: Measuring the predictive value of the Pediatric Emergency Care Applied Research Network rules in under 2-year-old patients

Brain CT scan	PECARN		Total
	+	−	
+	50	5	55
−	6	112	118
Total	56	117	173

PECARN: Pediatric Emergency Care Applied Research Network, CT: Computed tomography

Table 5: Measuring the predictive value of the Pediatric Emergency Care Applied Research Network rules in above 2-year-old patients

Brain CT scan	PECARN		Total
	+	−	
+	25	0	25
−	7	45	52
Total	32	45	77

PECARN: Pediatric Emergency Care Applied Research Network, CT: Computed tomography

Conclusions

According to the results of the present study, PECARN rules have a significant association with brain CT scan findings. Therefore, using these rules in recommended to reduce the number of brain CT scan requests for pediatric patients, especially in patients above 24 months old with no false-positive results. Further studies are recommended with a larger sample size for the applicability of this rule in the management of pediatric head trauma. It is also recommended to compare the PECARN rules with other rules in this regard. Furthermore, after approving these rules, training them is recommended for medical students.

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Conflicts of interest

There are no conflicts of interest.

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