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Research Article

PECARN rules for Non-contrast Brain CT scan in children under 2 years of age with minor head trauma

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Abstract:

Objective: The present study aims to investigate compliance with Pediatric Emergency Care Applied Research Network (PECARN) rules in the decisions for brain Computed tomography (CT) examination in children aged below two years old with minor head trauma.

Methods: In this retrospective study, 234 medical records of children with mild Traumatic brain injury (TBI) who had undergone brain CT scan in the emergency department of Namazi hospital in Shiraz, from March 2017 to February 2019 were assessed for meeting PECARN guidelines for CT scan indication. Data were analyzed for sensitivity and specificity.

Result: Among 234 patients who received CT examination, 187 (79.9%) patients met the PECARN rules criteria, and 47 (21.1%) patients did not meet PECARN rules. PECARN had a sensitivity and specificity of 93.05 and 41.11%, respectively, in predicting positive brain CT findings in children under two years. But, in our study, there were 10 cases of false-negative PECARN.

Conclusion: In this study, which was conducted by including all the predictor values of the PECARN guidelines, the rate of compliance with PECARN rules was 79.9 % which can be improved by using a computerized decision support system based on PECARN rules and help clinicians to reduce the rates of unnecessary CT scans. But there was a low specificity of 41.11% which might be due to retrospective evaluation of the medical records, warranting the need for further retrospective studies.

Keywords: Traumatic brain injury, Pediatric, Emergency medicine, X-ray Computed Tomography

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Introduction

Traumatic Brain Injury (TBI) happens when the brain is injured by an external mechanical force that is traumatic in character. This non-degenerative, non-congenital injury can cause permanent or temporary impairment of cognitive, physical, and psychosocial functions, as well as a lowered or changed level of awareness *(1)*.

Traumatic brain injury is the most common cause of mortality and disability in children around the world *(2)*. Children with mild head trauma have a low probability of brain damage and rarely require neurosurgery. For this purpose, the profit-loss balance between the risk of ionizing Computed tomography (CT) scan and the very low risk of

positive CT findings has led researchers to diagnostic criteria to avoid unnecessary CT scan imaging *(3)*. To decide between pediatric patients with head trauma who need a CT scan and patients who do not benefit from it, Pediatric Emergency Care Applied Research Network (PECARN) Pediatric Head Injury/Trauma Algorithm has developed an algorithm to diagnose children at risk of clinically important TBI (ciTBI) *(4, 5)*. There are many CT indication guidelines available as well as the Canadian Assessment of Tomography for Childhood Head Injury (CATCH) and Children's Head Injury Algorithm for the Prediction of Important Clinical Events (CHALICE); while only the validity of the PECARN is well addressed in the literature *(6)*. Prospective study comparing these three guidelines of CATCH, CHALICE, and PECARN, indicated highest sensitivity in PECARN for correctly requesting CT scan *(7)*. The validity of this algorithm in different studies has been evaluated. In a multicenter study, the sensitivity of this algorithm was reported to be 100% in children under two years and 99% in children over two years. The extent to which PECARN recommendations are used in pediatric hospitals is not well understood *(8, 9)*.

According to our information, so far, no study has been conducted at Namazi Educational and Medical Center on the correctness of CT scan indication for ciTBI in children under two years of age. For this purpose, in this study, the medical records of patients under two years of age referred to the pediatric emergency department of Namazi Hospital in the 2019 year were examined and based on the PECARN algorithm, the CT scan indications were evaluated for each case.

Methods:

This retrospective study was performed on children under two years of age who underwent a brain CT scan without contrast injection with a diagnosis of minor head trauma. Minor head trauma was defined as Glasgow Coma Scale (GCS) ≥14 . Access to medical records was approved by an IRB with a code of IR.SUMS.MED.REC.1399.077 (available at: https://bit.ly/3lVVofu; link shortened). Descriptive patient characteristics of this dataset are published in Volume 10, Issue 4, of the International Journal of Medical Investigation *(10)*.

All records registered with the impression of head trauma with the age of under two years in the Emergency Department of Namazi Hospital, Shiraz, Iran, from January 2017 to March 2019, enter the statistical population of the study.

Census sampling of the statistical population was performed with recuring records with eligibility criteria of minor head trauma with the age of under 2 years old who had undergone a non-contrast brain CT scan. A total of 2136 record files were extracted from the hospital database. Exclusion criteria were uncompleted records.

Based on the PECARN, variables of GCS; the presence of palpable skull fracture, signs of Altered mental status (AMS) including Agitation, somnolence, repetitive questioning, or slow response to verbal communication; Occipital, parietal, or temporal scalp hematoma ;history of decreased Level of consciousness more than 5 seconds; not acting normally per parent; and mechanism of injury were recorded along with demographic data and CT scan results. CT scans were reported by radiologists.

PECARN Guideline

According to the PECARN Guideline flowchart, in the first stage, the clinical signs of palpable skull fracture, AMS, Decreased Level of consciousness of more than five seconds, and not acting normally per parent were considered as predictive factors for CT scan and were defined as study variables. In the second stage of PECARN, if one of the cases (presence of hematoma, history of decreased LOC above 5 seconds, presence of one of the severe mechanisms of injury or not acting normally per

parent) was positive, a CT would be performed according to the following conditions: Physician experience, Multiple findings in the clinical exam, Worsening of symptoms, Age under 3 months, and Parents preference.

Because medical records were filled up by separate Emergency Medicine experts, requests for CT scans were made by different radiologists, and scans were reported by multiple radiologists, it's probable that misinterpretation of clinical and imaging findings occurred in this study; while the retrospective design of this study did not lead us estimating various aspects of this kind of bias, as a study limitation.

Statistical analysis: After collecting information based on the designed checklist, qualitative information was expressed as n (%) and quantitative variables were expressed as Mean ± SD. Sensitivity and Specificity were analyzed using MedCalc Software *(9)*. A Chi-square test was used to compare qualitative data. Quantitative variables were compared with proper tests based on the variable normality. SPSS version 20 was used to analyze the dataset, considering a two-tailed P-value lower than 0.05 as statistically significant.

Results:

A total of 234 patients under two years of age were eligible for the study. The mean age of patients was 12.06±6.84 months. The youngest patient was a day old and the oldest patient was 24 months old. There were 122 (47.9%) male and 112 (52.1%) female subjects. There were 25 (10.7%) patients with a GCS of 14 and 209 (89.3%) patients with a GCS of 15. Altered mental status happened in 29 patients, presenting as agitation in 10 (4.3%) and somnolence in 19 (8.1%). The records showed that 22 (9.4%) had a reduced level of consciousness above five seconds. Also, 10 cases (4.3%) had abnormal performance behavior according to parents' opinion.

Table 1. Characteristics of the study population

Variables		Value (n=234)
Age, mean (months)		12.06±6.84
Sex, n (%)	Male	122 (52.1%)
	Female	112 (47.9%)
GCS, n (%)	15	209(89.32%)
	14	25(10.68%)
Palpable skull fracture, n, %		1 (0.4%)
AMS, n (%)	Agitation	10(4.27%)
	Somnolence	19(8.12%)
	Repetitive questioning	0(0%)
	Slow response to verbal communication	0(0%)
	Without AMS	205(87.61%)
Decreased level of consciousness more than 5 seconds, n, %		22(9.4%)
Not acting normally per parent, n, %		10(4.2%)
Scalp hematoma, n, %	Parietal	16(6.84%)
	Occipital	11(4.7%)
	Temporal	7(2.99%)
Mechanism of Trauma, n, %	Motor vehicle accident with patient ejection	2(0.85%)
	Death of another passenger	0(0%)
	Rollover	6(2.56%)
	Pedestrian or bicyclist without helmet struck by motorized vehicle	8(3.42%)
	Fall from >0.9m	125(53.42%)
	Head struck by a high-impact object	12(5.13%)
	None	81(34.62%)
Alternative CT indication, n, %	Physician experience	101(43.16%)
	Multiple findings in clinical exam	17(7.26%)
	Worsening of symptoms	0(0%)
	Age under 3 months	29(12.39%)
	Parents preference	0(0%)
CT scan findings, n, %	Contusion	19 (8.12%)
	Intracranial hemorrhage	1 (0.43%)
	Basal Skull fracture	8 (3.42%)
	Linear Skull Fracture	75 (32.05%)
	Subdural hemorrhage	13 (5.56%)
	Epidural hemorrhage	12 (5.13%)
	Subarachnoid hemorrhage	5 (2.14%)
	Depressed Skull Fracture	11 (4.7%)
	Normal CT scan	90 (38.46%)

Trauma mechanism was falling from a height in 125 (53.4%) cases; rollover in 6 (2.6%); head struck by a high-impact object in 12 (1.5%); motor vehicle

accident (MVC) with patient ejection in 2 (0.9%); accident of a pedestrian or cyclist without a helmet with a motor vehicle in 8 (3.4%); and non-severe mechanisms in the rest, as shown in Table 1.Based on the PECARN, 187 (79.9%) cases of our study were indicated for CT scan; while 47 (20.1%) patients did not need CT scan, Kolmogorov-Smirnov test showed a significant difference (P<0.001), as shown in figure 1.

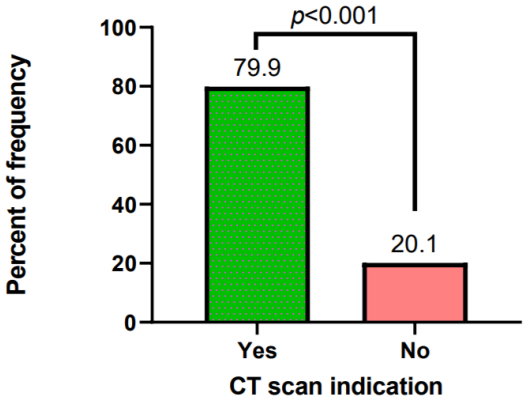

Figure 1. PECARN CT indication percent among study subjects

The number of true positive cases, including those that were indicated by PECARN and CT scan findings was 134. Also, the number of false negatives, including those in which there was no indication for a CT scan but the CT scan was positive, was 10 subjects.

Table 2. Sensitivity/ Specificity analysis of PECARN algorithm vs. positive CT scan findings

	Value	95% CI
Sensitivity	93.06%	87.600% to 96.620%
Specificity	41.11%	30.842% to 51.982%
Positive likelihood ratio	1.58	1.322 to 1.889
Negative likelihood ratio	0.169	0.088 to 0.323
Positive predictive value	71.66%	67.902% to 75.135%
Negative predictive value	78.72%	65.956% to 87.603%
AUC	0.671	0.607 to 0.731
Accuracy	73.08%	66.910% to 78.649%

The sensitivity of the PECARN algorithm was estimated to be 93.05%. The number of true negative cases, including those in which there was no indication for CT scan and the CT scan result was negative, was 37 subjects. False-positive cases include 53 cases in which there was an indication for a CT scan while a normal CT scan result was found, the specificity of the PECARN algorithm was 41.11%, shown in table 2.

Discussion:

Distinguishing whom to be evaluated by a CT scan and patients with no need to CT scan is a necessity to prevent unrequired CT scan exposure in pediatric. We used a previously suggested guideline called PECARN algorithm in our medical institute to determine level of compliance with international guidelines. Our study revealed high sensitivity of PECARN (93.06%) in the diagnosis of ciTBI which is associated with positive brain CT scan findings. Our estimated specificity was 41.11% that is relatively low to consider PECARN as a definitive diagnosis algorithm; while totally a good accuracy of 73.08% was observed. In the review of literature, there are many studies on this topic. In a multicenter study by Ballard et al. from 2011 to 2014 in five Pediatric Emergency Centers and eight public emergency centers on patients less than 18 years with blunt head trauma, PECARN was shown to be an electronic tool for decision making. Using PECARN in those centers, the rate of CT scan requests decreased significantly from 24.2% to 21.6%. Also in this study, it has been reported that using PECARN, none of the cases of ciTBI were ignored *(10)*; while in our study, there were 10 cases of false negatives. It might be due to the retrospective application of PECARN in our study. But in their study, both younger and older than two years old cases were being evaluated; while we just assessed younger than 2 years cases.

In another single-center study, 6851 Emergency department visits of patients younger than 21 years had shown that the use of the CT according to the PECARN guideline causes a 6% decrease in CT scan requests using PECARN *(11)*. Considering 37 (15.81%) true negative cases and 53 (22.64%) false positives in our study, our results show that PECARN application would be associated with a 6.81% increased number of unnecessary CT scans. But this difference in mentioned studies is due to the retrospective design of our study and if we educate clinicians to use PECARN, a better outcome would be achieved. As in our study, a great percentage of CT requests were performed due to Physician experience in 101 (43.16%) cases, which highly biases the study results. In a prospective study in Turkey on 262 children under two years of age, it has been shown that 47.7% of all brain CT requests did not meet the criteria PECARN, and resulted in no ciTBI *(12)*; while we did not see such a pattern. In Iran, a study in Tehran on ٥٩٤ children in two emergency centers based on the PECARN found that PECARN sensitivity and specificity were 92.3 and 40.6% for all patients and 100.0 and 57.8% for younger than two years patients, respectively *(13)*. This is very similar to our study estimates. That study showed that physicians decide to request CT scans for 44.6% of patients who did not need CT scans based on the PECARN. This statement could not be compared with our study results as we just included patients who had undergone a brain CT scan.

Also, in the main prospective cohort study of PECARN algorithm in 2009, younger than two-year-old subjects in the Derivation population, where the prediction was not the same as it is today, had 98.6% sensitivity and 53.7 % specificity, while their validation population, which is more representative of current PECARN algorithm, had 100% sensitivity and 53.6 % specificity *(5)*, which is consistent with our findings. However, no cases of neurosurgery were overlooked in their research.

Limitations of the study:

Among the limitations of this study are the small sample size of patients, the centrality of the study to select patients, the retrospective study design and lack of access to patients to evaluate their symptoms, lack of follow-up patients to evaluate any development of ciTBI after discharge.

A missing part in all of these researches is that in our retrospective study, 43.16% of cases were alternatively underwent CT scan due to physician experience; while to our knowledge, a psychological factor that is greatly affecting this decision is the fear of medical errors, that might lead the physician to perform a CT scan in some cases to avoid further legal claims. Also, a more important issue is that in a motor vehicle accident and pedestrian or bicyclist accidents in Iran, imaging studies are needed for legal application for legal and insurance third-parties, even in case of susception of child abuse.

Conclusion:

The rate of compliance with PECARN rules was 79.9% in this study, which was conducted using all of the predictor values of the PECARN guidelines. This rate can be improved by using a computerized decision support system based on PECARN rules, which can help clinicians reduce the rate of unnecessary CT scans. However, the poor specificity of 41.11 percent might be attributable to the retrospective review of medical data, necessitating the need for more prospective research.

Consent For Publication:

Not applicable.

Availability of Data and Materials:

No other data than what is presented in this paper is available.

Competing interests:

None.

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Authors' contributions:

RS and ZS designed the study. RSMRA and MM queried the medical records and included eligible subjects. Data were analyzed by ZS and MM. drafting of the manuscript was performed by RS and MM. All authors confirmed the final version of the paper.

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References:

1. Stocchetti N, Conte V, Ghisoni L, Canavesi K, and Zanaboni C. Traumatic brain injury in pediatric patients. Minerva Anestesiol 2010, 76*(12)*:1052–9. PubMed

2. Langlois JA, Rutland-Brown W, Thomas KE. Traumatic brain injury in the United States. In: CDC, ed. National Center for Injury Prevention and Control, 2006.

3. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. NeuroRehabilitation. 2007 Jan 1;22*(5)*:341-53. PubMed

4. Nishijima DK, Yang Z, Urbich M, Holmes JF, Zwienenberg-Lee M, Melnikow J, Kuppermann N. Cost-effectiveness of the PECARN rules in children with minor head trauma. Annals of emergency medicine. 2015 Jan 1;65*(1)*:72-80. PubMed

5. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD, Atabaki SM, Holubkov R, Nadel FM, Monroe D, Stanley RM, Borgialli DA, Badawy MK. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. The Lancet. 2009 Oct 3;374(9696):1160-70.

6. Babl FE, Borland ML, Phillips N, Kochar A, Dalton S, McCaskill M, Cheek JA, Gilhotra Y, Furyk J, Neutze J, Lyttle MD. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. The lancet. 2017 Jun 17;389(10087):2393-402. PubMed

7. Lyttle MD, Crowe L, Oakley E, Dunning J, Babl FE. Comparing CATCH, CHALICE and PECARN clinical decision rules for paediatric head injuries. Emergency Medicine Journal. 2012 Oct 1;29*(10)*:785-94. PubMed

8. Schonfeld D, Bressan S, Da Dalt L, Henien MN, Winnett JA, Nigrovic LE. Pediatric Emergency Care Applied Research Network head injury clinical prediction rules are reliable in practice. Archives of disease in childhood. 2014 May 1;99*(5)*:427-31. PubMed

9. Babl FE, Borland ML, Phillips N, Kochar A, Dalton S, McCaskill M, Cheek JA, Gilhotra Y, Furyk J, Neutze J, Lyttle MD. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. The lancet. 2017 Jun 17;389(10087):2393-402. PubMed

10. Sadegh R, Salehi Z, Mousavi Rokn Abadi R S, Sharifi M. Descriptive Study of Physical and Imaging Examination of Head Trauma in Children Under 2 Years of Old. Int J Med Invest. 2021; 10 *(4)*. URL: http://intjmi.com/article-1-682-en.html

11. MedCalc Software Ltd. Diagnostic test evaluation calculator. https://www.medcalc.org/calc/diagnostic_test.php (Version 20.014; accessed October 20, 2021)

12. Ballard DW, Kuppermann N, Vinson DR, Tham E, Hoffman JM, Swietlik M, Davies SJ, Alessandrini EA, Tzimenatos L, Bajaj L, Mark DG. Implementation of a clinical decision support system for children with minor blunt head trauma who are at nonnegligible risk for traumatic brain injuries. Annals of emergency medicine. 2019 May 1;73*(5)*:440-51. PubMed

13. Nigrovic LE, Stack AM, Mannix RC, Lyons TW, Samnaliev M, Bachur RG, Proctor MR. Quality improvement effort to reduce cranial CTs for children with minor blunt head trauma. Pediatrics. 2015 Jul 1;136*(1)*:e227-33. PubMed

14. Gerilmez A, Calışaneller AT. Compliance with PECARN head injury decision rules in children under two years old. Ulusal Travma ve Acil Cerrahi Dergisi. 2020;26*(3)*:462-8 . PubMed

15. Nakhjavan-Shahraki B, Yousefifard M, Hajighanbari MJ, Oraii A, Safari S, Hosseini M. Pediatric Emergency Care Applied Research Network (PECARN) prediction rules in identifying high risk children with mild traumatic brain injury. European journal of trauma and emergency surgery. 2017 Dec;43*(6)*:755-62. PubMed