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ORIGINAL ARTICLE

Comparison of PECARN and CATCH clinical decision rules in children with minor blunt head trauma

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Abstract

Introduction and purpose Computerized brain tomography (CBT) imaging plays a key role in the management of patients with head trauma, and there is an indication for CBT in moderate and severe injuries. However, it is difficult to determine an indication for CBT in patients with minor head trauma. The primary aim of this study is to compare the efficiency of the most commonly used clinical decision rules: the guidelines of the Pediatric Emergency Care Applied Research Network (PECARN), and those of the Canadian Assessment of Tomography for Childhood Head Injury (CATCH).

Methods The study, which was designed as a prospective cohort study, sought to determine the appropriate CBT indications for children younger than 18 years who were referred to the emergency department with minor blunt head trauma. The effectiveness of PECARN and CATCH clinical decision rules, which are recommended by literature to be applied in order to diagnose severely injured patients and minimize inappropriate CBT requests, was investigated. All patients included in this study were younger than 18 years of age, were admitted to the study with an isolated blunt head trauma, had a GCS of >13, and had parental permission to participate in the study. Patients ages 18 and older, those with penetrating head trauma or trauma to other systems, those with GCS ≤ 13, those with incomplete data, and those whose parents did not agree to participate in the study, were excluded.

Results A total of 256 patients were included in the study. PECARN and CATCH rules were both shown to be statistically significant in detecting the presence of pathology ($p<0.001$, $p=0.002$, respectively). Overall, PECARN was more successful than CATCH in detecting intracranial pathology. The sensitivity of PECARN was 95 (95% CI 72–100%) and specificity was 53 (95% CI 47–60%), while the sensitivity of CATCH was 48 (95% CI 25–71%) and specificity was 83 (95% CI 79–88%). Multivariate regression analyses were performed on the parameters (low GCS, abnormal mental status, age, non-frontal hematoma) and other parameters (vomiting, headache, abnormal behavior according to parents) that were considered to be clinically significant despite having a p value of <0.3. Age, low GCS, and non-frontal hematoma presence were found to be significant in predicting the presence of pathology. In particular, low GCS increased the probability of pathology 5.94-fold and non-frontal hematoma presence 4.37-fold.

Conclusion While both PECARN and CATCH were found to be effective in determining the necessity of CBT for children with minor blunt head trauma, PECARN proved to be more useful for emergency services because of its higher sensitivity. The authors suggest that conducting a CBT scan based on clinical decision rules may be a suitable approach for early detection of the presence of intracranial acute pathologies in young children with minor blunt head trauma, especially if the GCS score is <15 and non-frontal hematomas are present.

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Keywords Blunt head ınjury · Clinical decision making · Computerized tomography

Introduction

Traumatic brain injury is one of the major causes of death in children. Computerized brain tomography (CBT) imaging plays a key role in the management of patients with head trauma, and there is an indication for CBT in moderate and severe injuries [1, 2]. However, it is difficult to determine an indication for CBT in patients with minor head trauma.

Clinically significant intracranial injury is present in only 1% or less of patients with minor head trauma. It is not cost effective to administer CBT to every child with minor head trauma, nor is it justifiable in terms of patient benefit because of the risks of radiation exposure [3–5]. For these reasons, clinical decision rules have been developed to determine whether a patient with minor blunt head trauma has an indication for CBT.

The primary aim of this study is to compare the efficiency of the most commonly used clinical decision rules: the guidelines of the Pediatric Emergency Care Applied Research Network (PECARN), and those of the Canadian Assessment of Tomography for Childhood Head Injury (CATCH). The secondary objective is to determine which of the subparameters included in these rules are most effective in detecting the presence of intracranial pathology.

Methods

Study design

The study, which was designed as a prospective cohort study, was carried out in an education and research hospital with an 836-bed capacity in Istanbul, Turkey, between 1/1/2016 and 4/30/2016. The annual mean patient admission to the hospital's emergency department, where the study was done, is 586,000 patients; of these, approximately 163,000 are children and 423,000 are adults. The ethics committee approval for the study was received from the ethics committee of the same hospital (approval no: BD2531547422).

This study sought to determine the appropriate CBT indications for children younger than 18 years who were referred to the emergency department (ED) with minor blunt head trauma. The effectiveness of PECARN and CATCH clinical decision rules, which are recommended by literature to be applied in order to diagnose severely injured patients and minimize inappropriate CBT requests, was investigated. In addition, each of the parameters forming these rules was assessed separately for its efficiency in detecting intracranial pathology.

Patient inclusion and exclusion criteria

All patients included in this study were younger than 18 years of age, were admitted to the study with an isolated blunt head trauma, had a Glasgow Coma Scale Score (GCS) of >13, and had parental permission to participate in the study. Patients ages 18 and older, those with penetrating head trauma or trauma to other systems, those with GCS ≤ 13, those with incomplete data, and those whose parents did not agree to participate in the study, were excluded.

Management of patients and collection of data

A CBT scan was performed on all patients who were admitted to the emergency department with an indication for CBT according to any of the PECARN or CATCH clinical decision rules or who were suspected of having a CBT for any other reason according to the clinician's decision. The decision on whether CBT was needed was made by an emergency medical specialist. The CBT results were reported by a radiologist who was blind to the study. When these two sets of clinical decision rules were applied to patients with an indication for CBT during emergency treatment, the answers to the questions of specificity, susceptibility, and probable superiority were sought if one rule outperformed another. The parameters that constitute the clinical decision rules include age, unconsciousness, vomiting, trauma mechanisms, and the presence of abnormal behavior according to the patient's family. Signs of skull fracture, scalp hematoma, and abnormal mental status, descriptive data, such as the sex of the patients and the time of the application, were also recorded. In addition, patients were given a GCS score based on initial assessments. A modified GCS score was applied to patients ages 0–5. The pathologies detected by CBT were classified and recorded as linear fracture, skull base fracture, epidural hematoma, compression fracture, parenchymal hemorrhage, contusion, and subdural hematoma. Patients were divided into two main groups—with and without intracranial pathology—according to their CBT scan results. The effectiveness of the clinical decision rules was compared, and their efficacy in predicting the presence of intracranial pathology was evaluated.

The presence or absence of the above-mentioned intracranial pathologies in computerized brain tomography constitutes the end point of the both PECARN and CATCH decision rules. Some authors of similar studies consider the end point to be clinically significant pathologies which require surgery, but this issue is controversial. We believe that it is difficult to detect clinically meaningful intracranial pathologies, and that this can only be determined retrospectively. For this reason, the presence of the above-mentioned pathologies in CBT was identified as the actual end point of the study. The patients were divided into two groups—with and without abnormalities according to CBT—and comparisons were made between the groups. In addition, these pathologies were also classified according to whether they were clinically significant. The classification was based on the parameters of Stiell et al. According to these parameters, > 4 mm subdural hematoma, any epidural hematoma, depressed fractures, subarachnoid hemorrhage more than 1 mm thick, > 5 mm cerebral contusion, and intraventricular hemorrhage were accepted as significant clinical pathologies [6].

Statistical analysis

SPSS 16.0 for Windows® was used to analyze the data. The normal distribution fitness of the data was determined by the Kolmogorov–Smirnov test. The data that matched the normal distribution were expressed as mean and standard deviation, while the rest were expressed as median and percentage. The Mann–Whitney *U* test was used in the comparison of non-normal distribution data while the Chi square test was used in the comparison of frequency data. The sensitivity and specificity of PECARN and CATCH in predicting intracranial pathology were determined, and the positive and negative likelihood values were calculated. Univariate and multivariate regression analyses were conducted on all parameters that constituted the two clinical decision rules to determine whether the parameters accurately predicted the presence of pathology. Parameters statistically significant in detecting the presence of pathology in CBT were included in the analysis of multivariate regression when appropriate criteria were set for the regression model according to the results. In addition, it was considered appropriate to accept the parameters which were not statistically significant ($p < 0.3$)* but were thought to be clinically meaningful into the multivariate regression model. Since there was a high correlation between low GCS score and abnormal mental status, the criterion of abnormal mental status was removed from the multivariate regression model. In conclusion, the multiregression model included age, GCS score, vomiting, headache, and non-frontal hematoma. According to the Omnibus test, the fit of the multiregression analysis model was found good.

*A *p* value of < 0.05 was considered statistically significant in the analyzes.

Results

A total of 278 patients who met the inclusion criteria were admitted to emergency department during the study. Fifteen of them did not agree to participate in the study, while seven were excluded because of data loss and/or lack of CBT reports. As a result, 256 patients were included in the study. The clinical characteristics of the patients are shown in Table 1.

Table 1 The clinical characteristics of the patients

	Patients *N* (%)
Age (median, IQR)	3 (1–7.75)
Sex (male/female)	153/103 (59.8–40.2%)
Symptoms/signs	
Vomiting	34 (13.3)
Abnormal behaviour according to parent	25 (9.8)
Headache	34 (13.3)
Abnormal mental status	31 (12.1)
Head fracture doubt during examination	0 (0)
Scalp hematoma all	119 (46.5)
Frontal hematoma	71 (27.7)
Occipital hematoma	18 (7)
Parietal hematoma	21 (8.2)
Temporal hematoma	6 (2.3)
Parietal + temporal hematoma	1 (0.4)
Frontal + parietal hematoma	2 (0.8)
Loss of consciousness**	0 (0)

IQR Interquartile range

**When PECARN was administered, if the duration of unconsciousness in children < 2 years was > 5 s, loss of consciousness was considered as positive

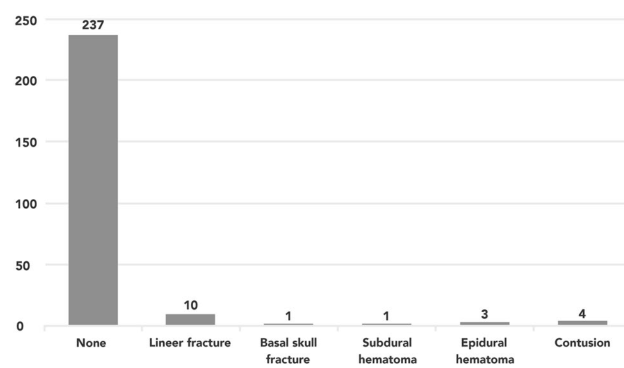

Fig. 1 Clinically important brain injuries

According to the methodology, patients with a GCS score of 14 or 15 were included in the study. It was determined that 225 patients (87.9%) had a GCS score of 15, and 31 patients (12.1%) had a GCS score of 14.

No skull fracture was suspected in any patient during examination. Figure 1 shows the distribution of pathologies detected by CBT.

241 patients (94.1%) were discharged after emergency service observation, and 15 (5.9%) were admitted to the brain and neurosurgery clinic after initial treatment. No

patients included in the study were in need of operation or intensive care, and no patients died.

Pediatric Emergency Care Applied Research Network (PECARN) and CATCH rules were both shown to be statistically significant in detecting the presence of pathology ($p < 0.001$, $p = 0.002$, respectively).

In the study, PECARN failed to detect a significant pathology in one patient. The patient's CBT revealed a basilar skull fracture and a linear fracture, and the patient was admitted to the brain surgery department. He was observed for 2 days and was discharged without surgical intervention. CATCH failed to detect the pathology in the same patient. One case of subdural hematoma, two cases of cerebral contusion, three cases of epidural hematoma, and three cases of linear fractures were caught by PECARN but missed by CATCH. Overall, PECARN was more successful than CATCH in detecting intracranial pathology. The performance results of both tests are detailed in Table 2.

According to the results of the statistical analysis that was performed to determine whether each parameter in the PECARN and CATCH clinical decision rules makes a significant difference in discerning the presence of a pathology, age, abnormal mental status, low GCS score (GCS = 14), and the presence of non-frontal hematoma were found to be statistically significant. However, it was found that vomiting, loss of consciousness, headache, abnormal behavior according to parents, presence of severe mechanisms of injury, and sex do not make a statistically significant difference in detecting the presence of pathology. Table 3 shows the results of the univariate analysis of the relevant parameters.

Multivariate regression analyses were performed on the parameters [low GCS (GCS = 14), abnormal mental status, age, non-frontal hematoma] and other parameters (vomiting, headache, abnormal behavior according to parents) that were considered to be clinically significant despite having a p value of < 0.3. Age, low GCS (GCS = 14), and non-frontal hematoma presence were found to be significant in predicting the presence of pathology. In particular, low GCS increased the probability of pathology 5.94-fold and non-frontal hematoma presence 4.37-fold. The relevant test results are given in Table 4. Because the parameters of GCS, abnormal mental status, and the presence of abnormal behavior according to parents had similar results and affected each other during the analysis, only GCS was included in the multivariate regression analysis.

Table 2 Test performances of PECARN and CATCH clinical decision rules

PECARN	Scalp fracture and/or intracranial bleeding in CBT		
	Positive	Negative	Total
Positive	18	111	129
Negative	1	126	127
Total	19	237	256
Sensitivity (CI)	95% (72–100%)		
Specificity (CI)	53% (47–60%)		
Positive predictive value (CI)	14% (9–21%)		
Negative predictive value (CI)	99% (95–100%)		
Positive likelihood ratio (LR+)	2 (1.7–2.4)		
Negative likelihood ratio (LR−)	0.1 (0.015–0.7)		
CATCH	Positive	Negative	Total
Positive	9	38	47
Negative	10	199	209
Total	19	237	256
Sensitivity (CI)	48% (25–71%)		
Specificity (CI)	83% (79–88%)		
Positive predictive value (CI)	19% (1–34%)		
Negative predictive value (CI)	95% (91–98%)		
Positive likelihood ratio (LR+)	2.95 (1.69–5.15)		
Negative likelihood ratio (LR−)	0.63 (0.41–0.96)		

PECARN Pediatric Emergency Care Applied Research Network, *CATCH* Canadian assessment of tomography for childhood head injury, *CBT* computerized brain tomography, *CI* %95 confidence interval

Table 3 Univariate regression analysis of parameters that may be associated with pathology in CBT

	Wald	p value	OR	95% CI
Age	6.357	0.012	0.788	0.655–0.948
GCS	9.919	0.002	5.177	1.861–14.403
Vomiting	1.047	0.306	0.343	0.044–2.660
Headache	0.000	0.998	0.000	0.000
Non-frontal hematoma	6.618	0.010	3.582	1.355–9.468
Abnormal mental status	9.919	0.002	5.177	1.861–14.403
Abnormal behaviour according to parent	0.882	0.364	1.832	0.495–6.783

CBT Computerized brain tomography, *GCS* Glasgow coma scale, *CI* 95% confidence interval

Table 4 Multivariate regression analysis of parameters that may be associated with pathology in CBT

	Wald	p value	OR	95% CI
Age	4.642	0.031	0.804	0.660–0.981
GCS	9.238	0.002	5.943	1.883–18.757
Vomiting	1.882	0.170	0.220	0.025–1.914
Headache	0.000	0.998	0.000	0.000
Non-frontal hematoma	7.165	0.007	4.371	1.484–12.872
Constant	0.000	0.997	0.000	

CBT Computerized brain tomography, *GCS* Glasgow coma scale, *CI* 95% confidence interval

Discussion

Each year, more than 450,000 children in the United States seek emergency medical service for blunt head trauma, and most of these cases are minor head trauma [7]. Traumatic brain injury (TBI) is one of the leading causes of death and disability, and any age, race/ethnicity, and income can be affected by this condition [8].

The Glasgow coma scale (GCS) is one of the oldest and most commonly used scoring systems for the evaluation of patients with head trauma. GCS scores are frequently used in the classification of patients with head trauma into subgroups, diagnosis and treatment modalities, and the serial evaluation of patients [7]. In many studies, a reduction in GCS score has been associated with brain injury [8–11]. In this study, low GCS scores (GCS = 14) were expected in the multiregression analysis in which the symptoms and findings of patients were used to predict the discovery of pathology via CBT. It was found to be effective in determining the presence of pathology. It was calculated that the chance of pathology is 5.94 times greater in patients with a GCS score of 14 than in those with a GCS score of 15. This result is not surprising, but confirms the view that most patients with low GCS scores require CBT examination. It can, therefore, be proposed that CBT is an appropriate method of diagnosis for children with blunt head trauma, except for those with a GCS score of 15.

According to studies by Dayan and colleagues, the occurance of isolated vomiting was found to be low in patients with clinically significant brain injury [12]. Clinically significant traumatic brain injury is rarely reported in patients who have single incidents of vomiting after minor head trauma. In a systematic review by Bressan and colleagues, it was noted that vomiting was not a sufficient marker for distinguishing the presence of intracranial hemorrhage [13]. Also, in the present study, the multiregression analysis showed that the occurrence of vomiting did not make a significant difference in determining the presence of pathology. However, because incidents of repeated vomiting were not investigated in this study, no comment can be made on whether repeated vomiting is a signal of the presence of pathology, nor can the prognostic effect be discussed. In the study performed by Dayan and colleagues, no correlation was found between traumatic brain injury and the amount of vomiting [12].

Although Güzel and colleagues found vomiting and headache to be among the most common symptoms in head trauma patients, only headache was found to have a correlation with the results of CBT. Vomiting and headache have been reported as weak risk factors in many studies [14]. In a retrospective study of 230 patients performed by Smith et al., it was reported that 30% of patients with mild head injuries were referred to the emergency department because of headache. Headache was the most common reason for referral, followed by unconsciousness (25.2%), post-traumatic amnesia (24.3%), and nausea/vomiting (10.4%) [15]. In the present study, headache was found to be an indicator of pathology in only 13.3% of patients, and it made no statistically significant difference in predicting the presence of pathology in CBT.

In similar studies, CBT revealed intracranial pathology in 4–6% of children with minor blunt head trauma. Clinically significant pathological CBT findings were discovered in 1–2% of all patients, and only 0.2–0.4% of patients required surgical treatment [13, 16, 17]. In the present study, CBT revealed pathology in 7.4% of patients, and clinically significant pathological CBT findings were detected in 2.7%; none of the patients required surgical treatment. These data confirm the view that CBT should not be a routine part of minor blunt head trauma treatment. Therefore, the authors of this study support the use of clinical decision rules such as PECARN and CATCH in emergency services and believe it will reduce unnecessary CBT requests.

Among the patients with clinically significant pathology, the most common condition was contusion, which was seen in four patients. This was followed in frequency by epidural hemorrhage (three patients) and subdural hemorrhage (one patient). In the study by Easter et al., skull fractures and subarachnoid hemorrhages were the most frequently reported clinically significant pathologies [16, 18].

Scalp hematoma is considered a useful indicator of underlying fractures, especially in infants under 1 year of age with minor head injuries. Many researchers recommend radiologic imaging for these patients [19, 20]. In studies performed, non-frontal scalp hematoma location and size were found to be important markers in skull fracture detection [20, 21]. In the present study, scalp hematomas were detected in 46.5% of patients; 27.7% of these hematomas were frontal, 0.8% were frontal + parietal hematomas and 18% were non-frontal hematomas. According to the results of the multivariate logistic regression analysis in the present study, non-frontal hematoma presence was significant in predicting the presence of pathology in CBT; the chance of pathology in CBT increased by 4.37 fold. However, none of these patients needed surgery. Although prospective studies show that children with head trauma have isolated scalp hematomas commonly (e.g. patients without signs and symptoms of brain damage), acute medical treatment or surgery is not required. As patient age decreases, especially in infants under 6 months, isolated scalp hematoma appears to increase in significance as an indicator of brain injury and pathology in traumatic CBT [22]. Based on the results of this study and information from literature, a CBT scan may be a correct approach to treating children under the age of one who have blunt minor head injuries with non-frontal hematomas.

In a study by Schonfeld et al. which investigated the safety of PECARN administration, it was reported that PECARN could be used for the detection of children at very low risk for TBI in children with minor blunt head trauma [23]. In a prospective cohort study comparing physician predictions on PECARN, CATCH, and CHALICE rules in treating children with minor head trauma, Easter et al. reported that PECARN was superior to other clinical decision rules. In this study, the sensitivity results of PECARN, CATCH, and CHALICE were 98, 90, and 64%, respectively; the specificity results were 64, 45, and 86%, respectively; the positive likelihood ratio values were 2.4, 1.6, and 4.4, respectively; and the negative likelihood ratio values were 0, 0.2, and 0.4, respectively. In the same study, the sensitivity of the physician's prediction was 96%, and the specificity was 51%; the positive likelihood ratio value was 2, and the negative likelihood ratio value was 0.1 [18].

In the present study, both PECARN and CATCH rules proved to be statistically significant in detecting pathology. The sensitivity and specificity of PECARN were calculated at 95 and 53%, respectively. The positive predictive value was calculated at 14%, and the negative predictive value was calculated at 99%. Again, this test had a positive likelihood ratio value of 2 and a negative likelihood ratio value of 0.1. The sensitivity and specificity of CATCH were calculated at 48 and 83%, respectively, with a positive predictive value of 19% and a negative predictive value of 95%. This test had a positive likelihood ratio value of 2.95 and a negative likelihood ratio value of 0.63. The results of the study overlap with the results of Easter et al. in this respect [18].

The present study results indicate that PECARN has higher sensitivity than CATCH [24]. Although there were a few cases in which both tests resulted in false negatives, patients who were later shown to be positive via CBT did not need surgical intervention or intensive care. The authors of the study believe it is more appropriate to apply PECARN in emergency departments because PECARN is more sensitive.

The regression analysis that was conducted to determine which set of parameters is more effective suggests the superiority of PECARN. In particular, low GCS score (GCS < 15) and the presence of non-frontal hematoma are the most effective parameters in pathology determination. According to CATCH, patients with GCS < 15 for longer 2 h are considered high-risk patients, while patients with GCS 14 are considered low-risk. However, in PECARN, all patients with GCS < 15 are considered at-risk regardless of the amount of time that has passed, and a CBT scan is recommended after initial evaluation. Additionally, the presence of non-frontal hematoma is a criterion that is unique to PECARN, and it is a highly effective parameter in predicting pathology in CBT. In addition, the results of the multiregression analysis show that the probability of pathology in CBT decreases as patient age increases, meaning that pathology is seen more frequently in CBT in younger children. PECARN's precise recommendations have clear benefits for children < 2 years of age. On the other hand, the less sensitive regulations of CATCH may not be as beneficial for younger children. Therefore, the authors have concluded that these parameters make PECARN superior to CATCH.

Although our results found PECARN superior to CATCH, unfortunately all clinical decision rules have limitations. As CBT has disadvantage of radiation exposure, magnetic resonance imaging would be a better choice, especially for younger children with minor head trauma until we find better new procedures.

Conclusion

The results of this study show that the implementation of clinical decision rules reduces the number of unnecessary CBT scans. While both PECARN and CATCH were found to be effective in determining the necessity of CBT for children with minor blunt head trauma, PECARN proved to be more useful for emergency services because of its higher sensitivity. The authors suggest that conducting a CBT scan based on clinical decision rules may be a suitable approach for early detection of the presence of intracranial acute pathologies in young children with minor blunt head trauma, GCS score is < 15 and non-frontal hematomas are present.

Limitations

The greatest limitation of the study is that it is single-centered. It is unadvisable to generalize outcome of a single-centered study, as the efficacy of rules affecting clinical practice, particularly clinical decision rules, may vary between hospitals. Although the number of patients in the study is high enough to provide statistically reliable results, the authors believe that the results of a multi-centered study and a study involving more patients will be more reliable.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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