RESEARCH ARTICLE

Samet Dinc[1]
Adem Kurtulus[2]
Necmettin Coban[3]
Cengiz Tuncer[4]
Ayhan Tekiner[5]

[1] Neurosurgery Clinic, Ankara Etlik City Hospital, Ankara, Türkiye
[2] Department of Neurosurgery, Eskisehir City Hospital, Eskisehir, Türkiye
[3] Neurosurgery Clinic, Afyonkarahisar State Hospital, Afyonkarahisar, Türkiye
[4] Department of Neurosurgery, Düzce Üniversity, Düzce, Türkiye
[5] Department of Neurosurgery, Ankara Training and Research Hospital, Ankara, Türkiye

Corresponding Author:
Samet Dinc
mail:dincsamet89@hotmail.com

Received: 26.05.2024
Acceptance: 06.01.2025
DOI:10.18521/ktd.1490160

Retrospective Examination of the PECARN Algorithm in Pediatric Patients with Minor Head Trauma

ABSTRACT

Objective: We aimed to retrospectively evaluate and examine pediatric head trauma cases according to PECARN in the light of their neurological and clinical conditions. We wanted to contribute to the detection of TBI with minimum CT imaging rates in order to avoid radiation-related carcinogenesis.

Method: 108 pediatric patients who were admitted to the emergency department due to minor head trauma and were admitted to the neurosurgery clinic were evaluated retrospectively.

Results: During follow-up, 9 patients required intensive care and 5 patients underwent neurosurgical surgery. The most common trauma etiology was falling from one's own level with 53.7%. The most common tomography pathology was non-displaced fracture. According to the evaluations made in accordance with the PECARN algorithm, CT was recommended in 18 cases (16.7%); CT was not recommended for 32 cases.

Conclusions: The clinician's goal is to quickly and accurately diagnose clinically significant TBI while avoiding unnecessary CT imaging to protect against the adverse effects of radiation. We recommend using the PECARN algorithm for this purpose.

Keywords: Head Trauma, Carcinogenesis, Tomography.

Minör Kafa Travmalı Pediatrik Hastalarda PECARN Algoritmasının Retrospektif Olarak İncelenmesi

ÖZET

Amaç: Pediatrik kafa travması olgularını nörolojik ve klinik durumları ışığında PECARN'a göre retrospektif olarak değerlendirmeyi ve incelemeyi amaçladık. Radyasyona bağlı karsinogenezi önlemek için minimum BT görüntüleme oranlarıyla TBI tespitine katkıda bulunmak istedik.

Yöntem: Minör kafa travması nedeniyle acil servise başvuran ve beyin cerrahi kliniğine başvuran 108 çocuk hasta retrospektif olarak değerlendirildi.

Bulgular: Takip sırasında 9 hastanın yoğun bakıma ihtiyacı oldu ve 5 hastaya beyin cerrahisi ameliyatı uygulandı. En sık görülen travma etiyolojisi %53,7 ile kendi seviyesinden düşmeydi. En sık görülen tomografi patolojisi deplase olmayan kırıktı. PECARN algoritmasına göre yapılan değerlendirmelere göre 18 olguya (%16,7) BT önerildi; 32 olguya BT önerilmedi.

Sonuç: Klinisyenin amacı, radyasyonun olumsuz etkilerinden korunmak için gereksiz BT görüntülemeden kaçınarak, klinik açıdan anlamlı TBI'yı hızlı ve doğru bir şekilde teşhis etmektir. Bu amaçla PECARN algoritmasını kullanmanızı öneririz.

Anahtar Kelimeler: Kafa Travması, Karsinogenez, Tomografi

Konuralp Medical Journal
e-ISSN1309–3878
konuralptipdergi@duzce.edu.tr
konuralptipdergisi@gmail.com
www.konuralptipdergi.duzce.edu.tr

INTRODUCTION

Traumatic brain injury (TBI) is the leading cause of trauma-related morbidity and mortality in the paediatric age group (1). Falls are the most common cause of head trauma in all age groups. Birth trauma is the main etiology of almost all neonatal head traumas. The mechanism of trauma in the first 2 years is non-accidental injuries. In young children and adolescents, the most common mechanisms of TBI are falls and motor vehicle crashes (2).

Mild TBI accounts for 70-90% of head traumas in children. Patients with a Glasgow Coma Scale (GCS) score of 13-15 after blunt head trauma are defined as mild TBI (3,4). Mild TBI may also be used interchangeably with the terms minor head injury or concussion (4,5).

Although the prevalence of minor head trauma is very high, it has been documented that 3-5% have TBI and less than 1% require emergency neurosurgical procedures (6,7).

In paediatric patients presenting with head trauma, radiological assessment is performed according to the severity of the trauma as well as clinical evaluation. Since the 1970s, computed tomography (CT) has been a tool that enables rapid and accurate decision making in the evaluation of closed head traumas, detection of intracranial pathologies and determination of treatment options (8,9). There is consensus on the indication for brain CT in moderate and severe head trauma in many paediatric trauma guidelines. However, brain CT indications in mild head traumas are not clearly demarcated (10,11). Many studies have emphasised the need to establish algorithms to reduce unnecessary CT imaging in paediatric minor head injury patients (11). By performing CT imaging in the presence of certain symptoms such as vomiting, headache, unconsciousness, and otherwise observing without CT imaging, it is suggested that unnecessary CT imaging and potential harm of radiation in paediatric patients with minor head trauma can be prevented (9,12). The life expectancy after radiation exposure is longer in the paediatric age group and they are more sensitive to radiation than adults. For these reasons, the primary goal in paediatric minor head trauma is to predict TBI with minimum CT scan rates to avoid radiation-related carcinogenesis (13,14).

Algorithms for minor head injuries in children have been designed after three major clinical trials. These are CHALICE (Children's Head Injury Algorithm for the Prediction of Important Clinical Events), CATCH (Canadian Assessment of Tomography for Childhood Head Injury) and PECARN (Paediatric Emergency Care Applied Research Network) (10,15,16). PECARN is a prospective cohort study of blunt head trauma patients under 18 years of age who presented within the first 24 hours of trauma, and unlike others, patients under two years of age were analysed separately (13,15,17). Although sensitivity and negative predictive values were high in all three studies, PECARN missed fewer patients (7,18). In this study, we aimed to retrospectively evaluate pediatric head trauma cases hospitalised and treated in our centre according to the PECARN algorithm in the light of their neurological and clinical status at the time of admission.

MATERIAL AND METHODS

Study Design: In this study, 108 paediatric patients admitted to the emergency department of Afyonkarahisar State Hospital between January 2019 and June 2021 for minor head trauma and treated in the neurosurgery clinic were retrospectively assessed. Ethics committee approval was obtained from Afyonkarahisar Health Sciences University Clinical Research Ethics Committee (date: 15.12.2023 number: 2023/12).

Patient Selection: Patients under the age of 18 who presented to the emergency department of Afyonkarahisar State Hospital in the first 24 hours of trauma due to minor head trauma and were hospitalised and treated by the neurosurgery clinic were included in the study.

Patients over 18 years of age, with a history of previous cranial surgery, known haematological disease, chronic disease/malignancy involving the central nervous system and patients with gunshot wounds/penetrating head trauma were not included in the study.

Data Collection: Patient data were obtained retrospectively from electronic health records and patient charts. Demographic (age, gender), trauma etiology, clinical (neurological status, need for operation and intensive care, etc.) and radiological data (pathology type and location) were collected.

Clinical and Radiological Evaluation: Neurological status, GCS, open wound and scalp swelling and symptoms were investigated. Symptoms included severe headache, unconsciousness and vomiting. All patients underwent detailed neurological examination and evaluation by a neurosurgeon. In addition, neurosurgical operation and intensive care needs of the patients were also mentioned.

Brain CT scans of all patients were performed using Siemens Healthineers SOMATOM Emotion CT 78560 device. The pathologies of the patients were classified as epidural haematoma, subdural haematoma, non-deplaced fracture, deplaced fracture, traumatic subarachnoid haemorrhage, contusio cerebri and pneumocephalus. Pathological locations were also specified. Cases requiring hospitalisation even though no traumatic pathology was detected on CT images were also included. The PECARN algorithm was applied retrospectively for each patient by two neurosurgeons in a consensus manner, taking into account the clinical status of the patients at the time of presentation.

Statistical Analysis: Statistical analyses were performed using IBM Statistical Package for the Social Sciences (SPSS) version 25.0 (IBM Corpotation, Armonk, NY). Normality of distrubitions was assessed by Kolmogorov-Smirnov test. Frequency (%) analysis was used for demographic analyses. Continuous variables were expressed as mean ± standard deviation and/or median (Inter Quartile Range) and categorical data were expressed as number and percentage. Chi-square tests were used to analyse the crosstabulations created for categorical data. $p<0.05$ was considered statistically significant.

RESULTS

Baseline Demographic and Clinical Characteristics: Demographic and clinical characteristics of the patients are summarised in Table 1. The mean age in months was 47.8 ± 4.6 (mean ± SEM). The median was 24 and the range was 1-204 months. There was a male gender predominance in this cohort (71 males, 37 females).

Table 1. Baseline demographic and clinical characteristics

Variable	n (%)
Demographic	
Sex, female	40 (37)
Age (month)	
mean ± SEM	47.8 ± 4.6
median (IQR)	24 (1-204)
Trauma etiology	
Fall	100 (92.6)
from standing	58 (53.7)
from height	34 (31.5)
bicycle (unhelmeted)	3 (2.8)
swing	5 (4.6)
MVC	5 (4.6)
passenger	1 (0.9)
pedestrian	4 (3.7)
Impact with a hard object	3 (2.8)
GCS	
15	96 (88.9)
<15	12 (11.1)
Symptoms	
Headache	10 (9.3)
Vomiting	11 (10.2)
Unconsciousness	12 (11.1)
Scalp swelling	68 (63)
Wound	23 (21.3)
Additional traumatic pathology	4 (3.7)
Need for ICU	9 (8.3)
Need for surgery	5 (4.6)
Length of stay hospital (day)	
mean ± SD	3 ± 1.8
median (IQR)	2 (1-9)

SEM: *Standard Error of Mean* ***SD:*** *Standard Deviation* ***GCS:*** *Glasgow Coma Scale* ***MVC:*** *Motor Vehicle Crash* ***ICU:*** *Intensive Care Unit* ***IQR:*** *Inter Quartile Range*

GCS was <15 in 11.1% of the patients and 30.6% had symptoms. In addition, 63% had scalp swelling and 21.3% had open wounds. While 9 patients required intensive care, 5 patients underwent neurosurgical surgery (Table 1). The mean hospital stay was 3 ± 1.8 days (mean ± SD).

Trauma Etiology: Trauma etiologies of the patients are summarised in Table 1. The etiologies were subdivided into falls, motor vehicle crashes and hard object impacts. The most common pathology was fall from standing level with 53.7%. The least common trauma etiology was motor vehicle crash which was seen in 1 patient.

Radiological Characteristics: The radiological characteristics of the patients are summarised in Table 2. The most common pathology was non-deplaced fracture (80.6%). The most common pathological location was parietal region (31.5%). In 10 patients, no trauma-related intracranial radiological pathology was observed on CT imaging at the time of presentation.

PECARN Evaluation: The PECARN algorithm was utilised for each case considering the clinical and neurological status at the time of admission. In accordance with the algorithm, it was taken into consideration that the patients were under and over 2 years of age. According to the judgements made in accordance with the PECARN algorithm, CT was indicated in 18 cases (16.7%), while 32 cases (29.6%) were not indicated. Chi-square analysis of all relevant variables according to the PECARN algorithm is shown in Table 3.

Table 2. Radiological characteristics

Variables	n (%)
Presence of pathology	98 (90.7)
Type of pathology	
Epidural haemorrhage	10 (9.3)
Subdural haemorrhage	5 (4.6)
Traumatic subarachnoid haemorrhage	4 (3.7)
Cerebral contusion	12 (11.1)
Non-deplaced fracture	87 (80.6)
Deplaced fracture	4 (3.7)
Pneumocephalus	7 (6.5)
Location of pathology	
Frontal	30 (27.8)
Temporal	7 (6.5)
Parietal	34 (31.5)
Occipital	16 (14.8)
Frontoparietal	4 (3.7)
Frontotemporal	4 (3.7)
Frontotemporoparietal	1 (0.9)
Temporoparietal	2 (1.9)

Table 3. PECARN evaluation chi-square analysis

		PECARN			p
		CT required n (%)	Observation vs. CT using shared decision-making n (%)	CT not indicated n (%)	
Presence of radiological pathology	+	13 (13.3)	53 (54.1)	32 (32.7)	**0.005**
	-	5 (50)	5 (50)	0 (0)	
Non-deplaced fracture	+	8 (9.2)	50 (57.5)	29 (33.3)	**<0.001**
	-	10 (47.6)	8 (38.1)	3 (14.3)	
Deplaced fracture	+	4(100)	0 (0)	0 (0)	**0.001**
	-	14 (13.5)	58 (55.8)	32 (30.8)	
EDH	+	2 (20)	4 (40)	4 (40)	0.658
	-	16 (16.3)	54 (55.1)	28 (28.6)	
SDH	+	2 (40)	1 (20)	2 (40)	0.187
	-	16 (15.5)	57 (55.3)	30 (29.1)	
Traumatic SAH	+	0 (0)	4 (100)	0 (0)	0,236

	-	18 (17.3)	54 (51.9)	32 (30.8)	
Cerebral contusion	+	4 (33.3)	4 (33.3)	4 (33.3)	0.163
	-	14 (14.6)	54 (56.3)	28 (29.2)	
Pneumocephalus	+	1 (14.3)	3 (42.9)	3 (42.9)	0.864
	-	17 (16.8)	55 (54.5)	29 (28.7)	
Presence of symptom	+	12 (50)	12 (50)	0 (0)	**<0.001**
	-	6 (7.1)	46 (54.8)	32 (38.1)	
Headache	+	3 (30)	7 (70)	0 (0)	0.085
	-	15 (15.3)	51 (52)	32 (32.7)	
Vomiting	+	5 (45.5)	6 (55.5)	0 (0)	**0.009**
	-	13 (13.4)	52 (53.6)	32 (33)	
Unconsciousness	+	12 (100)	0 (0)	0 (0)	**<0.001**
	-	6 (6.3)	58 (60.4)	32 (33.3)	
Wound	+	6 (26.1)	6 (26.1)	11 (47.8)	**0.011**
	-	12 (14.1)	52 (61.2)	21 (24.7)	
Scalp swelling	+	7 (10.3)	49 (72.1)	12 (17.6)	**<0.001**
	-	11 (27.5)	9 (22.5)	20 (50)	
Additional traumatic pathology	+	3 (75)	1 (25)	0 (0)	**0.016**
	-	15 (14.4)	57 (54.8)	32 (30.8)	
Need for ICU	+	6 (66.7)	3 (33.3)	0 (0)	**<0.001**
	-	12 (12.1)	55 (55.6)	32 (32.3)	
Need for surgery	+	4 (80)	1 (20)	0 (0)	**0.003**
	-	14 (13.6)	57 (55.3)	32 (31.1)	
Trauma etiology	Fall from standing	4 (6.9)	29 (50)	25 (43.1)	**0.013**
	Fall from height	10 (29.4)	17 (50)	7 (20.6)	
	Fall (bicycle-unhelmeted)	1 (33.3)	2 (66.7)	0 (0)	
	Fall (swing)	1 (20)	4 (80)	0 (0)	
	MVC (passenger)	0 (0)	1 (100)	0 (0)	
	MVC (pedestrian)	0 (0)	4 (100)	0 (0)	
	Impact with a hard object	2 (66.7)	1 (33.3)	0 (0)	

PECARN: *Pediatric Emergency Care Applied Research Network* ***CT:*** *Computed Tomography* ***MVC:*** *Motor Vehicle Crash* ***ICU:*** *Intensive Care Unit* ***SAH:*** *Subarachnoid Haemorrhage* ***EDH:*** *Epidural Haemorrhage* ***SDH:*** *Subdural Haemorrhage*

DISCUSSION

The most common factor causing mortality in children is trauma, and among traumas, head traumas are both the most frequently seen and the most important cause of mortality(8,19). Falls, traffic accidents and sports injuries are the most prominent causes of head trauma and are more common in boys (8,12). In our study, it was observed that the majority of the cases were due to falls (92.6%). In addition, the majority of cases were boys (63%) in parallel with the literature. There is not yet a consensus on the indications for imaging especially in paediatric patients with minor head trauma. In the study by Easter et al. it was emphasised that clinician assessment and the PECARN algorithm define all clinically significant traumatic brain injury and PECARN is slightly more specific (20). In our trial, CT was not considered unnecessary in any patient requiring neurosurgical procedure and/or intensive care unit. In this respect, we think that the PECARN algorithm is a useful guideline for predicting traumatic brain injury and making the necessary imaging decision, regardless of the clinician's experience. Furtado et al. retrospectively examined paediatric minor head trauma patients for cost-effectiveness. For this evaluation, the PECARN algorithm was applied retrospectively and it was ascertained that CT was not required in 77.6% of the cases in which CT imaging was performed. According to this result, PECARN reduces the cost and this reduction is statistically significant (21). In our study, CT was not necessary in 32 cases (29.6%). However, some points should be remarked in this regard. Firstly, according to the PECARN algorithm, CT is not unnecessary in any patient undergoing neurosurgical procedures and/or requiring intensive care unit. Another point is that unlike other studies, our study was conducted on hospitalised patients requiring neurosurgical follow-up and treatment. These results emphasise that the PECARN algorithm is important in terms of cost reduction as well as predicting traumatic brain injury. Apart from the algorithms in the literature, there are recommendations for CT imaging indication and prediction of traumatic brain injury. Michiwaki et al. found that traumatic imaging findings were significantly more frequent in cases <1 year of age, GCS 14 and falls from height (22). Similarly, Andrade et al. showed that traumatic abnormal CT findings were statistically significantly higher in patients who fell from a distance of more than 1 meter (23). Fundaro et al. retrospectively investigated paediatric patients with mild head trauma and reported that scalp swelling and impaired consciousness were important findings in predicting traumatic brain injury requiring CT imaging (24). According to the PECARN algorithm, CT was not unnecessary in any patient with consciousness retardation in our study. In addition, CT was not necessary in 12 (17.6%) patients with scalp swelling in our study. In summary, CT indications in paediatric patients with minor head trauma should be carefully determined according to age, clinical status and mechanism of trauma, as well as the experience of the clinician. Algorithms in the literature have been tried to be established within this framework. When the sensitivity of the paediatric age group to radiation exposure with CT is considered, the aim of all these predictors is to maximally predict traumatic brain injury while minimising radiation exposure. In some studies in the literature, non-ionised imaging methods have also been researched in order to mitigate the adverse effects of radiation. Cicogan et al. evaluated point of care ultrasound (POCUS), near-infrared spectroscopy (NIRS) and rapid magnetic resonance imaging (MRI) methods. According to the PECARN algorithm, POCUS and NIRS can improve the decision-making process of the clinician in addition to PECARN in cases with moderate and severe risk for traumatic brain injury. Rapid MRI was seen as a suitable alternative to CT (25). In addition, the sensitivity of CT should be taken into consideration in the detailed diagnosis of bone pathologies.

CONCLUSION

Minor head traumas are frequently encountered especially in the paediatric age group. They are mostly not associated with traumatic brain injury and long-term sequelae. Children exposed to minor head trauma should be carefully evaluated by the clinician considering the history and findings suggestive of clinically significant TBI. The purpose of the clinician is to rapidly and accurately diagnose clinically significant TBI while avoiding unnecessary CT imaging to protect against the adverse effects of radiation. For this reason, various clinical decision-making algorithms have been proposed in the literature to assist the clinician. These algorithms are expected to have high sensitivity especially for the identification of cases requiring neurosurgical intervention and follow-up. We recommend the adoption of the PECARN algorithm for this purpose. On the other hand, similar studies should be performed in larger groups of patients requiring hospitalisation and neurosurgical follow-up and treatment as in our study.

Source of Funding: The authors declare the study received no funding.

Conflict of Interest: The authors declare that there is no conflict of interest.

Author Contributions: The authors confirm contribution to the paper as follows: study conception and design: SD, AK; data collection: SD, AK, NÇ; analysis and interpretation of results: SD, NÇ; draft manuscript preparation: AK, NÇ. All authors reviewed the results and approved the final version of the manuscript.

REFERENCES

1. Nigrovic LE, Kuppermann N. Children With Minor Blunt Head Trauma Presenting to the Emergency Department. Pediatrics. 2019;144(6).
2. Pinto PS, Meoded A, Poretti A, Tekes A, Huisman TA. The unique features of traumatic brain injury in children. review of the characteristics of the pediatric skull and brain, mechanisms of trauma, patterns of injury, complications, and their imaging findings--part 2. J Neuroimaging. 2012;22(2):e18-41.
3. Singh N, Singhal A. Challenges in minor TBI and indications for head CT in pediatric TBI-an update. Childs Nerv Syst. 2017;33(10):1677-81.
4. Lumba-Brown A, Yeates KO, Sarmiento K, Breiding MJ, Haegerich TM, Giogia GA, et al. Centers for Disease Control and Prevention Guideline on the Diagnosis and Management of Mild Traumatic Brain Injury Among Children. JAMA Pediatr. 2018;172(11):e182853.
5. Mayer AR, Quinn DK, Master CL. The spectrum of mild traumatic brain injury: A review. Neurology. 2017;89(6):623-32.
6. Özsaraç M, Karcıoğlu Ö, Topaçoğlu H, Ayrık C, Kıyan S, Sener S, et al. Clinical indicators of traumatic brain injury and skull fracture in pediatric head trauma patients. Turkish Journal of Emergency Medicine. 2009;9(4):153-8.
7. Babl FE, Borland ML, Phillips N, Kochar A, Dalton S, McCaskill M, et al. Accuracy of PECARN, CATCH, and CHALICE head injury decision rules in children: a prospective cohort study. Lancet. 2017;389(10087):2393-402.
8. Atabaki SM. Pediatric head injury. Pediatr Rev. 2007;28(6):215-24.
9. Karaoğlu Gündoğdu D, Şahinoğlu M, Köktekir E, Karabağlı H. Pediatric Head Injuries. Türk Nöroşir Derg. 2020;30(2):287-92.
10. Dunning J, Daly JP, Lomas JP, Lecky F, Batchelor J, Mackway-Jones K. Derivation of the children's head injury algorithm for the prediction of important clinical events decision rule for head injury in children. Arch Dis Child. 2006;91(11):885-91.
11. Klemetti S, Uhari M, Pokka T, Rantala H. Evaluation of decision rules for identifying serious consequences of traumatic head injuries in pediatric patients. Pediatr Emerg Care. 2009;25(12):811-5.
12. Er A, Akman C, Alataş İ, Ünlü HB, Ceylan I, Gün C, et al. Should Children with Minor Head Injury Routinely Have CT Scan?. JOPP Derg. 2013;5(3):131-135.
13. Lyttle MD, Crowe L, Oakley E, Dunning J, Babl FE. Comparing CATCH, CHALICE and PECARN clinical decision rules for paediatric head injuries. Emerg Med J. 2012;29(10):785-94.
14. Tomar Güneysu S, Derinöz Güleryüz O. Çocuklarda Minör Kafa Travmalarına Yaklaşım. 2022.
15. Osmond MH, Klassen TP, Wells GA, Correll R, Jarvis A, Joubert G, et al. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. CMAJ. 2010;182(4):341-8.
16. Bressan S, Eapen N, Phillips N, Gilhotra Y, Kochar A, Dalton S, et al. PECARN algorithms for minor head trauma: Risk stratification estimates from a prospective PREDICT cohort study. Acad Emerg Med. 2021;28(10):1124-33.
17. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD, Atabaki SM, Holubkov R, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. Lancet. 2009;374(9696):1160-70.
18. McGraw M, Way T. Comparison of PECARN, CATCH, and CHALICE clinical decision rules for pediatric head injury in the emergency department. CJEM. 2019;21(1):120-4.
19. Schutzman SA, Greenes DS. Pediatric minor head trauma. Ann Emerg Med. 2001;37(1):65-74.
20. Easter JS, Bakes K, Dhaliwal J, Miller M, Caruso E, Haukoos JS. Comparison of PECARN, CATCH, and CHALICE rules for children with minor head injury: a prospective cohort study. Ann Emerg Med. 2014;64(2):145-52, 52 e1-5.
21. Furtado LMF, da Costa Val Filho JA, Dos Santos AR, Furfuro R, Sandes BL, Hon Y, et al. Pediatric minor head trauma in Brazil and external validation of PECARN rules with a cost-effectiveness analysis. Brain Inj. 2020;34(11):1467-71.
22. Michiwaki Y, Maehara N, Ren N, Kawano Y, Nagaoka S, Maeda K, et al. Indications for computed tomography use and frequency of traumatic abnormalities based on real-world data of 2405 pediatric patients with minor head trauma. Surg Neurol Int. 2021;12:321.
23. Andrade FP, Montoro RN, Oliveira R, Loures G, Flessak L, Gross R, et al. Pediatric minor head trauma: do cranial CT scans change the therapeutic approach? Clinics (Sao Paulo). 2016;71(10):606-10.
24. Fundaro C, Caldarelli M, Monaco S, Cota F, Giorgio V, Filoni S, et al. Brain CT scan for pediatric minor accidental head injury. An Italian experience and review of literature. Childs Nerv Syst. 2012;28(7):1063-8.
25. Cicogna A, Minca G, Posocco F, Corno F, Basile C, Dalt LD, et al. Non-ionizing Imaging for the Emergency Department Assessment of Pediatric Minor Head Trauma. Front Pediatr. 2022;10:881461.