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Effect of parental pressure on emergency physicians for computerized tomography imaging request in children with head trauma

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ABSTRACT

Background: Both minor and major head traumas constitute an important proportion of childhood emergency admissions. In this study, the findings of cranial computed tomography (CCT) scans performed as a result of the parental pressure were evaluated.
Methods: The frequency and findings of CCT scans performed as a result of parental pressure were examined in a separate subgroup.
Results: A total of 227 patients were included in the study; 158 (69.9%) patients had undergone CCT scans; a pathological finding was detected in 24 (10.6%) of these patients and undergone a consultation by the neurosurgeon (most common finding was isolated linear fracture; n = 12; 50%). The patients undergoing CCT scans were divided in two subgroups: the PECARN group [n = 123 (77.8%)] and the Parental pressure group [n = 33 (22.2%)].
Conclusion: One third of the parents of children who presented to the emergency department with head trauma and had no indication for CCT according to PECARN rules insisted on CCT imaging, and none of these cases showed ciTBI, surgical operation, or mortality. None of the patients in the parental pressure group had a history of surgical intervention or mortality within one month after discharge.

1. Introduction

Both minor and major head traumas constitute an important proportion of childhood emergency admissions. Rapid identification of intracranial lesions due to trauma plays a pivotal role in preventing possible brain damage [1]. Although computed tomography (CT) is a rapid and effective method for the detection of intracranial pathologies due to trauma, it is known that children are more susceptible to radiation-induced cell damage [1,2]. CT not only involves the risk of radiation exposure, but also the risk of acute side effects of sedative agents given during the imaging studies [3,4]. Although the rate of positive results has decreased in recent years, the number of imaging studies with cranial computed tomography (CCT) scans are gradually increasing in children admitted with head trauma [1,5].

To reduce radiation exposure in the pediatric age group, the indication of CCT needs to be properly evaluated. Therefore, various clinical decision-making rules have been established [1]. One of these, the Pediatric Emergency Care Applied Research Network (PECARN), is used to identify children at very low risk of severe brain injury. PECARN includes different clinical decision-making rules for children under and over two years of age and aims to safely discharge children with minor head trauma who are free of clinically significant brain injury without performing CCT screening [6].

In our region, children with minor head trauma are brought to the emergency services by their parents with the request of imaging. This can often lead to various degrees of disagreement between physicians and parents or even physical violence. While the necessity of CCT imaging is decided by physicians according to the benefits and possible risks, the insistence of the parents regarding imaging studied makes it difficult for physicians to work.

In this study, we investigated the factors affecting physicians in determining the necessity of CCT in children admitted to the emergency

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department with head trauma. The findings of CCT scans performed as a result of the parental pressure were evaluated. The indication of CCT imaging was primarily based on PECARN rules.

2. Materials and methods

The study was conducted after the approval of the local Ethics Committee at Hasan Kalyoncu University (Date: 06/06/18; No: 2018–05). The study was designed as a prospective cohort study and carried out between 1st July and 30th November 2018 in the emergency departments of two state hospitals in Gaziantep. A total of 300.000–400.000 patients present to each emergency department where the study was conducted (approximately 3% of the cases are children with head trauma) and there is insufficient physical area to follow-up such a high number of patients. Both hospitals are the centers where pediatric trauma patients are primarily admitted as outpatients or via ambulance transport. In this study, the causes and findings of CCT scans of patients admitted to the emergency department with head trauma aged ≤16 years and admitted to both hospitals during the shifts of physicians were integrated. The frequency and findings of CCT scans performed as a result of parental pressure were examined in a separate subgroup. The PECARN rules were used to determine the indication for CCT. In accordance with these rules, the decision for CCT imaging or observation of the patients was made.

2.1. Implementation of PECARN rules

For children <2 years of age, CCT imaging is recommended for those with a GCS (Glasgow Coma Score) of ≤14 points, palpable skull fracture or in case of altered state of consciousness (Clinically significant risk of traumatic brain injury (ciTBI risk is 4.4%). In the same age group, CCT scans *or observation is recommended* (ciTBI risk is 0.9%) for children with a history of loss of consciousness for >5 s, temporal/parietal or occipital scalp hematoma, serious injury mechanism (ejection from a vehicle during a motor vehicle accident, death of another passenger or rolling and tumbling of the vehicle, pedestrian survivors, bike accidents with no helmet, falling from a height of >90 cm, falling of hard objects on the head), in case of abnormal behaviors according to parents/guardians. However, due to the heavy workload and the lack of sufficient physical area for observation at the participating hospitals, *CCT scans were performed on the patients in this case*. The patients who did not fulfill the above-mentioned criteria were considered as very low-risk patients, and observation was recommended for such patients (ciTBI risk is <0.02%).

For children >2 years of age, CCT imaging is recommended for those with a GCS of ≤14 points, altered state of consciousness, or skull fracture (ciTBI risk is 4.3%). In the same age group, CCT *or observation is recommended* (ciTBI risk is 0.8%) if there is a history of loss of consciousness and vomiting, severe headache or serious injury mechanism (ejection from a vehicle during a motor vehicle accident, death of another passenger or turning over and rolling of the vehicle, pedestrian survivors, bicycle accidents without helmet, falling from a height of >150 cm, falling of hard objects on the head). However, due to the heavy workload and the lack of sufficient physical area for observation at the participating hospitals, *CCT scan was performed on the patients in such cases*. The patients who did not fulfill the above-mentioned criteria were considered as very low-risk patients, and observation was recommended for such patients (ciTBI risk is <0.05%).

2.2. Process

- Patients with no indication for CCT scans (<2 and > 2 years of age with a ciTBI risk of <0.02% and < 0.05%; respectively) were observed for a maximum of two hours. CCT was planned when the clinical condition of the patients worsened. All parents were informed about the possible risks of radiation exposure of CCT scans and signed an informed consent form. If the patient's clinical condition did not deteriorate, he/she was discharged with recommendations.
- In cases where there is fear of medical malpractice in physicians and anxiety of exposure to violence in the emergency department due to extreme parental pressure of some patients who do not have any CCT indication and sometimes their attitudes towards verbal and physical violence; the parents who are expecting imaging have been informed about the possible risks of radiation exposure due to CCT imaging. However, CCT was performed after an informed consent form was signed by the parents expecting and persisting for a CCT imaging.
- Patients with an indication for CCT imaging [*for < 2 years, a high risk (<4.4%) and low risk (0.9%) for ciTBI; and for those > 2 years, a high risk (<4.3%) and low risk (0.8%) for ciTBI*] were kept in the emergency service for a maximum of 2 h unless a pathological finding (*subdural, epidural, subarachnoid, or intra-parenchymal hemorrhages; linear or collapse fractures*) was detected. When the patient's clinical condition deteriorates, follow-up CCT scans and consultation with a neurosurgeon were planned. If the patient's clinical condition did not deteriorate, he/she was discharged from the hospital with recommendations.
- Patients having CCT imaging indication *[ciTBI is at high risk (<4.4%) and low risk (0.9%) for < 2 years of age; ciTBI high risk (<4.3%) and low risk (0.8%) for > 2 years of age]* and those with pathological findings on CCT scans *(subdural, epidural, subarachnoid, intraparenchymal hemorrhages; linear or compression fractures)* were consulted by a neurosurgery specialist. In accordance with the recommendation of the neurosurgeon, the observation period in the emergency department was extended or the decision for hospitalization/operation was made.
- The parents of all patients with a CCT scans imaging indications were informed about the risks that may be caused by radiation exposure of CCT scans, and the patient's current status and benefit/harm ratio were explained to the parents.
- A total of 243 patients were evaluated during the study period, one month after their admission to the emergency department, their parents were contacted using the recorded contact information, and questioned about any follow-up CCT scans, surgical intervention or mortality within one month, and they were also called for a follow-up visit. The study was completed with 227 patients who agreed to participate in the study. The accuracy of the information given by the parents was verified by the hospital records.

Inclusion criteria

- ≤16 years of age
- Having presented during the first 24 h of head trauma

Exclusion criteria

- >16 years of age
- Having presented after 24 h or longer following head trauma
- To have a concomitant disease
- Those with a history of previous intracranial hemorrhage, skull fracture, and/or previous intracranial operation
- Penetrating head trauma

Measurements

- Descriptive statistics of patients
- The patients were divided into two groups: those who had undergone CCT scans imaging and those who had not. Age, GCS, cause of admission, scalp lesion, duration of observation at the ED, any follow-up CCT, surgical operation, and mortality within one month, and discharge rates from the ED were compared between the two groups.
- Patients undergoing CCT scans were studied in two subgroups: the

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PECARN group and Parental pressure group. CCT findings, surgical operations performed within one month, one month-mortality and discharge from ED rates were compared between these two subgroups.

2.3. Statistical analysis

The conformity of the numerical data for the normal distribution was tested with the Shapiro-Wilk test. The Student's *t*-test was used for the numerical variables showing normal distribution among the two independent groups, and the Mann-Whitney *U* test was used for the non-normally distributed numerical variables. A chi-square test was used to compare two independent groups in terms of categorical data. The results of descriptive statistics were given as mean ± standard deviation for the numerical variables and as numbers and % values for categorical variables. The SPSS for Windows version 24.0 package program was used for the statistical analysis and a p value of <0.05 was considered statistically significant.

3. Results

A total of 227 patients were included in the study; 146 (64.3%) of them were male and the mean age was 57.39 months [69 (30.4%) patients were ≤ 2 years of age]. The mean GCS of the patients was 14.88 points and the most common reason for admission (23.8%) was falling from a height of 90–150 cm. 130 (57.3%) patients had presented to the emergency department within the first hour after the trauma. 138 (60.8%) patients had scalp lesions (most common scalp lesion was laceration <1 cm; n = 43; 31,2%), which were mostly on the frontal region (54.5%). A total of 158 (69.9%) patients had undergone CCT scans; a pathological finding was detected in 24 (10.6%) of these patients and undergone a consultation by the neurosurgeon (most common finding was isolated linear fracture; n = 12; 50%), 5 (2.2%) of these patients had been discharged without any problem after 12 h of follow-up in the emergency department, while 19 (8.4%) had been hospitalized and treated. In the interview on call at the 1st month, we found that 18 (7.9%) of these patients had undergone follow-up CCT scans, 17 of whom consisted of the patients who had undergone CCT scans at the first presentation [12 of these patients had positive findings on CCT (2 post-operative and 10 follow-up due to clinical changes) and no additional findings were observed], while the other 2 patients had undergone control CCT due to clinical changes observed during their follow-up in the ED and no additional pathology was observed. The remaining 3 patients had been discharged from the first hospital and gone to the other hospital and undergone CCT due to parental pressure (2 of these patients had undergone CCT according to the PECARN criteria and one due to parental pressure in the first hospital). One patient in the group who did not undergo CCT was admitted to the hospital with a headache for 2 consecutive days following the trauma and no pathology was observed.

Two (1.6%) of the patients in the CCT group (0.9% of the study population) had undergone a surgical operation and been discharged without sequelae. One patient (0.4%) died who had been admitted due to a bomb explosion. None of the patients who had been discharged without CCT imaging, had undergone surgical intervention or developed mortality within one month.

A total of 158 patients had undergone CCT imaging; 50 (31.6%) of them were younger than 2 years of age. While 52 (32.9%) patients had high risk of ciTBI (4.4 & 4.3); 71 (44.9%) patients had low risk of ciTBI (0.8 & 0.9). There was no significant difference between the mean age of the patients with and without CCT imaging (58.54 months vs. 57.77 months; p = .563). The mean GCS (14.83 points) was lower in patients undergoing CCT scans (p = .043). There was no statistical difference between the two groups in terms of gender (p = .430). Patients undergoing CCT imaging had mostly been admitted due to a fall from a height of 90–150 cm (n = 45, 28.5%), while patients without CCT imaging had mostly been admitted with a fall at their own level (n = 26, 37.6%) (p = .001). There was no statistically significant difference between the two groups in terms of the arrival time at the ED (p = .214). There was no significant difference between the two groups in terms of the presence of scalp lesion and the localization of the scalp lesion (p = .074 and p = .177, respectively). In both groups, most [134 (84.4%) of the patients who had undergone CCT imaging and 69 (100%) of those who had not] were followed-up and discharged in 2 h at the latest (p = .008) (Table 1). We examined the patients undergoing CCT scans in two subgroups: the PECARN group [n = 123 (77.8%)] and the Parental pressure group [n = 33 (22.2%)]. 23 patients (18.6%) in the PECARN subgroup had abnormal CCT scans findings and had undergone the consultation of a neurosurgeon; two patients (1.6%) had undergone surgical intervention (discharged without sequelae), and one patient, who was brought after a bomb explosion, had died. *One patient in the 'parental pressure' subgroup had a linear fracture, who was hospitalized and discharged without sequelae. None of the patients in the parental pressure group had a history of surgical intervention or mortality within one month after discharge.* There was no statistically significant difference between the two groups in terms of CCT findings, surgical consultation and surgical intervention history within one month after discharge (p > .05) (Table 2).

4. Discussion

The aim of our study was to investigate the effect of parental pressure and other factors on emergency physicians in requesting CCT scans in children (16 years and under) presenting to the emergency department with head trauma. One of the primary questions asked in the anamnesis of a trauma patient admitted to the emergency department is the mechanism of trauma. The mechanism of trauma may sometimes be an indication for imaging alone [6,8]. Many studies have reported that the most common mechanism of trauma in children is falling (70% in Powel et al., 81% in Andrade et al., 47% in Klassen et al., and 52.6% in Alharthy et al.) [7-10]. The height of falls is considered as an important indicator of the severity of trauma and is a parameter that affects the tendency of performing CCT scans. In the study of Klassen et al., the authors reported that more CCT scans were requested in patients who had suffered a fall from a height > 90 cm compared to lower heights (OR = 3.4) and more abnormal imaging findings were found [9]. In the study by Osmond et al., intracranial pathology was observed 8 times more frequently in patients falling from a height > 90 cm than those falling from a height of <90 cm [5]. In our study, the most common reason for admission was falling (73.6%; n = 167) and approximately 1/3 of these cases had fallen from a height of >90 cm (54 cases had fallen from 90 to 150 cm and 25 cases had fallen from a height of >150 cm; 23.8% and 11%, respectively). The most common cause of admission among the patients who had undergone CCT scans had fallen from >90 cm [(90–150 cm and > 150 cm; 28.5% and 15.2% respectively) (p = .001).] Cranial pathology was observed in 13 of these patients (isolated fracture in 11 patients and intracranial hemorrhage in 2 patients); no patient required neurosurgical intervention or had died within one month.

Although self-level falling is not considered a serious trauma mechanism, in the study by Andrade et al., 30% of the patients who had undergone CCT scans comprised patients falling at their own level, and 7.9% of them had abnormal imaging findings [8]. In the study of Klassen et al., only 5 (1.7%) of 296 patients admitted due to falling from a height of <90 cm (including those falling from their own level). In our study, CCT was performed on 19 (42%) out of a total of 45 patients presenting with a fall from their own level (12% of all patients undergoing CCT). While 15 of these patients had undergone CCT scans according to PECARN rules (due to vomiting in 5 patients, loss of consciousness for 5 s in one patient, GCS <15 points in one patient, non-frontal hematoma in 6 patients and severe headache in 2 patients), CCT was performed in 4 cases due to parental pressure. Intracranial pathology was not observed

Table 1
Initial data of the patients

Variable	Total	Undergoing CCT	No CCT	p
Number of patients	227 (100%)	158 (69.6%)	69 (30.4%)	
Age (months)	57.39 ± 45.09 (1–198)	58.54 ± 46.78	54.77 ± 41.15	0.563
GCS	14.88 ± 0.59 (8–15)	14.83 ± 0.7	15 ± 0.1	**0.043***
Gender	Male (n = 146) 64.3% Female (n = 81) 35.7%	Male (n = 99) 43.6% Female (n = 59) 26%	Male (n = 47) 20.7% Female (n = 22) 9.7%	0.430
Admission cause				
<90 cm fall	(n = 31) 13.7%	(n = 17) 10.7%	(n = 14) 20.3%	
>150 cm fall	(n = 25) 11.0%	(n = 24) 15.2%	(n = 1) 1.5%	
90–150 cm fall	(n = 54) 23.8%	(n = 45) 28.5%	(n = 9) 13.0%	
Bike accident	(n = 12) 5.3%	(n = 9) 5.7%	(n = 3) 4.3%	**0.001***
Fall, unspecified	(n = 12) 5.3%	(n = 12) 7.6%	(n = 0) 0%	
Something hit to head	(n = 27) 11.9%	(n = 12) 7.6%	(n = 15) 21.8%	
Fall at his/her own level	(n = 45) 19.8%	(n = 19) 12%	(n = 26) 37.6%	
Traffic accident	(n = 21) 9.2%	(n = 20) 12.7%	(n = 1) 1.5%	
Admission duration				
<1 h	(n = 130) 57.3%	(n = 78) 49.1%	(n = 52) 75.4%	
1–6 h	(n = 25) 11.0%	(n = 16) 10.6%	(n = 9) 13%	0.214
7–24 h	(n = 13) 5.7%	(n = 11) 6.9%	(n = 2) 3%	
Unspecified	(n = 59) 26.0%	(n = 53) 33.4%	(n = 6) 8.6%	
Scalp lesion				
Yes	(n = 138) 60.8% Laceration < 1 cm (n = 43, 31.2%) Laceration > 1 cm (n = 38, 27.5%) Soft tissue swelling (n = 32, 23.2%) Superficial skin lesion (n = 25, 18.1%)	(n = 90) 56.7% Laceration < 1 cm (n = 29, 32.2%) Laceration > 1 cm (n = 25, 27.8%) Soft tissue swelling (n = 23, 25.6%) Superficial skin lesion (n = 13, 14,%4)	(n = 48) 69.1% Laceration < 1 cm (n = 14, 29.2%) Laceration > 1 cm (n = 13, 27.1%) Soft tissue swelling (n = 9, 18.7%) Superficial skin lesion (n = 12, 25%)	0.074
No	(n = 89) 39.2%	(n = 68) 43.3%	(n = 21) 30.9%	
Lesion localization				
Frontal	(n = 75) 54.5%	(n = 46) 51.1%	(n = 29) 60.5%	
Occipital	(n = 23) 16.6%	(n = 12) 13.3%	(n = 11) 22.9%	
Parietal	(n = 20) 14.4%	(n = 16) 17.8%	(n = 4) 8.3%	0.177
Temporal	(n = 8) 5.8%	(n = 7) 7.8%	(n = 1) 2.1%	
Facial	(n = 12) 8.7%	(n = 9) 10%	(n = 3) 6.2%	
Outcome				
Neurosurgeon consultation	(n = 24) 10.6%	(n = 24) 14.1%	(n = 0) 0%	0.001*
Discharge	(n = 203) 89.4%	(n = 134) 85.9%	(n = 69) 100%	
Monitoring duration				
12 h in ED	(n = 5) 2.2%	(n = 5) 3.6%	(n = 0) 0%	
2 h in ED	(n = 203) 89.4%	(n = 134) 84.4%	(n = 69) 100%	0.008*
Hospitalization	(n = 19) 8.4%	(n = 19) 12%	(n = 0) 0%	

* Significant at p < .05 level.

in any of the patients who had undergone CCT due to parental pressure. Among patients who had undergone CCT according to PECARN rules, subarachnoid hemorrhage was suspected in only one patient, who was monitored for 12 h in the emergency room and control CCT was found to be normal and hence, the patient was discharged home. In our study, the most common reasons for admission in patients who did not undergo CCT had fallen from their level or < 90 cm height (37.6% and 20.3%, respectively; p = .001); we observed that physicians tended to request fewer CCT scans in falls from low heights. None of the patients who had presented with a fall from their own level had been re-admitted to the emergency department, undergone any intracranial operation, and no mortality was observed in any of them following

Table 2
Subgroup analysis of patients who had undergone CCT.

	Total CCT scans (n = 158) 100%	PECARN subgroup (n = 123) 77.8%	Parental Pressure subgroup (n = 35) 22.2%	p
CCT Findings & neurosurgery consultation				
No	(n = 134) %85.9	(n = 100) % 81.4	(n = 34) % 97.1	
Yes	(n = 24) %14.1 ILF (n = 12; 50%) IDF (n = 3; 12.5%) SS (n = 1; 4.2%) SH (n = 2; 8.3%) DF + SAH (n = 2; 8.3%) EH (n = 1; 4.2%) SAH (n = 2; 8.3%) C+ SH (n = 1; 4.2%)	(n = 23) % 18.6 ILF (n = 11; 48.0%) IDF (n = 3; 13.0%) SS (n = 1; 4.3%) SH (n = 2; 8.7%) DF + SAH (n = 2; 8.7%) EH (n = 1; 4.3%) SAH (n = 2; 8.7%) C + SH (n = 1; 4.3%)	(n = 1) % 2.9 ILF (n = 1, 100%)	0.070
Operation history within one month				
Yes	(n = 2) 1.3%	(n = 2) 1.6%	(n = 0) 0%	0.750
No	(n = 156) 98.7%	(n = 121) 98.4%	(n = 35) 100%	

*Significant at p < .05 level; ILF: Isolated linear fracture; IDF: Isolated depressed skull fracture; SS: Suture separation; SH: Subdural hematoma, DF + SAH: Depressed fracture + Subarachnoid hemorrhage; EH: Epidural hematoma; SAH: Subarachnoid hemorrhage; C + SH: Contusion + Subdural hematoma.

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discharge. We think that the PECARN criteria are successful in determining the requirement for CCT scans in patients who falling from a height of <90 cm and at their level, if there are no additional neurological symptoms.

Isolated scalp abrasion and lacerations may not indicate serious trauma in trauma patients without additional findings; however, parietal, occipital and temporal hematomas, swelling of >5 cm, bruising and lacerations in children under 1 year of age may be a sign of serious trauma [1]. Scalp hematoma may be seen more frequently in children with head trauma under 2 years of age, but its value in predicting fracture and intracranial pathology is limited [7]. In a study by Gruskin et al., 122 (53.74%) of 227 patients had scalp lesions [11]. Of these, 37 (30.3%) had skull fractures and 11 (9%) had intracranial hemorrhage (whether fractured or not). On the other hand, in a study by Osmond et al., 114 (71.7%) of 159 patients with intracranial pathology did not have any scalp lesions [5]. In our study, 138 patients (60.8% of total patients) had scalp lesions. 90 of these patients (65.2% of patients with lesions) had undergone CCT scans. 14 (10.1%) patients had skull fractures, while 5 (3.6%; 2.2% of total patients) patients had intracranial hemorrhage (with or without fracture). In our study, there was no significant difference in the presence of scalp lesion between patients undergoing CCT and those who had not ($p = .074$). Accordingly, we can say that the presence of a scalp lesion does not affect the decision of CCT indication. Based on the evidence, the presence of a scalp lesion may be effective in deciding on requesting CCT scans, but the absence of any scalp lesion is not a factor that would exclude suspicion of intracranial pathology.

The fact that the potential risk of radiation exposure at early age indicates the importance of clinical decision-making rules in determining CT scans indication. In particular, children <2 years of age are unable to express themselves, the head/body ratio is greater and consequently the risk of head trauma is higher; only restlessness or the presence of scalp lesions (non-frontal hematoma, >5 cm lesion, etc.) can be considered as an indication for CCT alone at early ages (<2 years and <1 years of age) [5].

In the study by Klassen et al., they found that the mean age of patients undergoing CCT was higher than those who did not (10.8 years vs. 9.4 years, $p = .05$) [9]. However, in the same study, there was no significant difference in age between the patients with positive findings on CCT scans and those without ($p = .81$) [9]. Moreover, there are studies showing that there is no significant relationship between abnormal CCT findings and patient age [8,12]. In our study, approximately 1/3 of patients with and without CCT were younger than 2 years of age. Similar to the study by Klassen et al., the mean age of our patients undergoing CCT was numerically higher (58.54 months vs. 54.77 months), but this difference was not statistically significant ($p = .563$). We think that this may be due to increased physical activity and trauma risk as the age increases.

In children with minor head trauma with a GCS score of 14–15, >90% of CCT scans resulted as normal [13]. A low GCS score is a condition that requires exclusion of intracranial pathology, especially in trauma patients. The lower the GCS score, the higher the incidence of intracranial pathology [5]. Therefore, the current clinical decision-making algorithms (PECARN, CATCH, CHALICE) recommend performing CCT scan if GCS is <15 points [1,5]. In a study by Osmond et al., 8.8% ($n = 377$) of 3866 patients had admission GCS of <15 points. In the same study, ciTBI was found in 3.2% of cases with GCS = 15, in 10.6% of cases with GCS = 14, and in 15.8% of cases with GCS = 13 (the incidence of ciTBI increased as GCS decreased) [5]. In the study of Klassen et al., 11.9% of the 1164 cases included in the study had an initial GCS of <15, a total of 171 patients had undergone CCT imaging (34% of them had GCS <15). In the mentioned study, as the GCS decreased, the frequency of CCT imaging and abnormal CCT findings increased [9]. In our study, 18 (7.9%) of 227 patients had a GCS of <15. 11.9% of patients who had undergone CCT had a GCS of <15 and the GCS score of patients who had undergone CCT was lower than those who had not (14.8 ± 0.7 vs. 15 ± 0.1; respectively, $p = .043$). In our study, we observed that physicians tended to request CCT more frequently in patients with low GCS scores.

Over the years, CT has become more frequently performed for cranial imaging in children due to the widespread use, increased availability and cheapness of CT devices [5]. The rate of CCT scanning in children with head trauma range from 1/3 to 1/2 [6,14-16]. This rate was reported as 35.2% in the study of Kuppermann et al., 52.8% and 34.9% in the studies by Osmond et al. conducted in 2010 and 2018, respectively, 30.4% in the study of Kemp et al., 62% in the study of Palchak et al., and 88.2% in the study of Andrade et al. [5,6,8,14,16,17]. In our study, CCT imaging was performed in 69.6% of the patients. However, when the CCT scans that were deemed inappropriate by the physician, but performed due to parental pressure, were excluded, and this rate decreased to 54.2%, which is consistent with the literature. It is possible to further reduce these rates with the widespread application of clinical decision-making rules for CCT scans, the implementation of regulations supporting the physician's decision and better patient-physician communication.

The incidence of intracranial pathologies in children with head trauma was found to be <10% in most studies [5,7,18]. Although these pathologies vary from isolated skull fractures to epidural hematomas, the frequency of neurosurgical operation requirement is <1% [5]. In the study of Osmond et al., 159 (4.1%) of 3866 patients had positive CCT findings, 24 of whom (0.6%) had undergone a neurosurgical operation [5]. Of the 227 patients included in our study, an intracranial pathology was detected in 24 (10.6%) patients, and 2 of them (0.9%) had undergone neurosurgical surgery. These results of our study were consistent with the literature.

Traumatic brain injuries are one of the major causes of death and neurological dysfunction in children >1 year of age [13]. The mortality rate after minor head trauma is very low [7,9]. In the study of Osmond et al., no mortality was noted in 3866 patients [5]. Similarly, there was no mortality among 1006 patients with head trauma in the study by Andrade et al. [8]. In our study, mortality occurred in one (0.4%) patient who was brought to the emergency room with multi-trauma resulting from a bomb explosion (GCS = 8, intubated, 13 years, male).

The established clinical decision-making rules aim to determine children with low risk of traumatic brain injury and reduce the use of CCT in children with head trauma [5-7]. In the study by Kupperman et al., 96 patients (0.3% of the patients included in the study) had been re-admitted to another health institution and 5 (5.2%) of them were found to have traumatic brain injury [6]. In a study by Holmes et al., 11,058 of 13,543 patients with a GCS of 15–14 points were discharged from the hospital due to normal CCT scanning findings. Of the discharged patients, 197 (1.78%) had been re-admitted and control CCTs revealed traumatic pathology in only 5 (0.05%) patients. However, no patient had undergone a neurosurgical intervention [13]. In our study, 208 patients had been discharged from the emergency department, 4 (1.9%) of whom had been re-admitted to a hospital after discharge. These four patients had undergone CCT imaging at the second admission (2 due to PECARN eligibility, and 2 due to parental pressure), but none had intracranial pathology. These data support the idea that clinical decision-making rules make CCT use more effective.

Parents take the diagnosis and treatment decisions together with their physicians on behalf of their children. Parents are the individuals who give the anamnesis on behalf of the child and play an important role in enlightening the clinical presentation. In a survey study, 42% of parents of children with concussion symptoms declared that they would seek emergency care, while more than half said they would request a definitive diagnosis of the cause of the concussion [19]. In their study, Boutis et al. found that almost half of the parents of children who had been brought to the emergency room due to head trauma were aware of the potential risk of radiation [20]. In our study, we used PECARN rules when evaluating the indication for CCT scans in children with head trauma. According to the relevant rules, the decision for performing CCT scans can be left to the parents' preference in children with a ciTBI risk of 0.8% and 0.9% (<2 years and > 2 years, respectively) [6]. However, CBT is not recommended in children with a ciTBI risk of <0.02 and 0.05 (<2 years and > 2 years, respectively). *The parents' insisting desire to undergo CBT for such patients is one of the focusing points of our study*. We observed that 104 patients (45.8% of total patients) in our study had no indication for CCT scans according to PECARN rules. Parents of patients without any imaging indications were informed about both the patient's current condition and the possible risks of radiation exposure during CCT imaging. The parents of 69 (66.3%) patients without CCT indication were persuaded and did not insist on imaging and CCT was not performed; however, the parents of 35 (33.7%) patients persistently requested imaging. A linear fracture was observed in only one of the 35 CCT scans performed as a result of parental pressure, and this patient was followed-up in the hospital for 24 h and was discharged without any problem. None of these patients underwent an operation and none had mortality within 30 days, and no re-admission to the hospital with ciTBI symptoms was determined either. We believe that the clinical decision-making rules and trusting practitioners will save children from unnecessary radiation exposure and limit unnecessary health expenditures.

5. Conclusion

One third of the parents of children who presented to the emergency department with head trauma and had no indication for CCT according to PECARN rules insisted on CCT imaging, and none of these cases showed ciTBI, surgical operation, or mortality. 1.9% (n = 4) of the patients discharged from the emergency department according to the PECARN rules had re-admitted to the emergency department; as a result of follow-up CCT scans, there were no ciTBI, surgical operation, or mortality observed. It is difficult to reduce the radiation exposure caused by imaging in children due to the fear of malpractice in physicians, parental pressure, the number of emergency admissions, and the inadequate post-traumatic follow-up opportunities.

For this purpose, we think that the excessive imaging rate can be reduced significantly by;

- Raising public awareness of radiation exposure caused by unnecessary CCT scans,
- Reducing the heavy workload of the emergency services and applying relevant policies, especially in developing countries such as Turkey,
- Increasing the number of trauma patient follow-up units and staff in emergency departments, for patients with a low probability of ciTBI, who can be monitored without imaging,
- Implementing regulations to support the application of the physicians' decisions.

5.1. Limitations

The limitations of our study were as follows:

- A relatively low number of participating physicians and cases,
- Inclusion of patients with GCS <14 presenting with multi-trauma increased the rate of CCT scans.
- Not every child of the parent who wanted a CCT imaging had undergone CCT for ethical reasons. It was first attempted to persuade the parents, and 2/3 of them gave up this insistence. If these children had also undergone CCT scans, the results may have been different.

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Availability of data and materials

Submitted work is original and has not been published elsewhere in any language. Raw data are available for editor on request.

Informed consent

Written consent was obtained from all parents of patients.

Ethical approval

The study was approved by Ethics Committee of Hasan Kalyoncu University, Gaziantep province, Turkey (Date: 06/06/18; No: 2018-05).

Human rights

Authors declare that human rights were respected according to Declaration of Helsinki.

Declaration of competing interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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