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The role of repeat computerized cranial tomography in pediatric blunt head trauma

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Abstract

Introduction: Computed cranial tomography (CCT) is commonly used in emergency departments (EDs) for pediatric blunt head injury (BHI) management. Cranial tomography is also repeated often unnecessarily due to physicians' concerns about detecting the early onset of a possible new injury or progression of an existing one. This study aims to evaluate whether routine RCCT provides a significant change in patient management.

Material and methods: The study was performed as a 2-year retrospective analysis in the ED of a tertiary hospital. The medical records of pediatric BHI patients were reviewed, and the study included accessed data of 104 patients who underwent at least two CCT during their stay in the ED.

Results: The study included 104 out of 533 BHI patients. The mean age of these 104 patients was 6.2 years (median=4.5 years), and the majority were male (n=82, 78.9%). When the initial CCT results of the patients were analyzed, it was found that 51% (n=53) of the tomography results were normal. While there were substantial changes in 7 of the RCCTs, there were no significant changes in 97. Only 4 of these 7 patients who had significant changes were taken to the emergent operating room. None of these patients belonged to the group of patients whose CCT was classified as "normal" on admission ($p<0.05$).

Conclusion: According to our results, routine RCCT for BHI in pediatric patients did not result in a significant change in patient management.

Key words: blunt head injury, computed tomography, pediatric emergency medicine, radiation exposure

Introduction

Non-contrast computed cranial tomography (CCT) is often the preferred imaging modality for the rapid and early identification and treatment of pediatric patients with blunt head injury (BHI) in our country and around the world [1,2]. Although pediatric head injury management is well established by pediatric trauma life support guidelines and some clinical decision rules in the ongoing management of patients with a BHI in the emergency department (ED), mostly the general approach is to request routine repeat computed cranial tomography (RCCT) and evaluate it for the possibility of the occurring of a new injury or progressing the old ones [3]. The most commonly used general clinical decision-making rules for assessing pediatric blunt head trauma are Pediatric Emergency Care Applied Research Network (PECARN), the children's head injury algorithm for the prediction of important clinical events [CHALICE], and Canadian assessment of tomography for childhood head injury [CATCH] rules [4-6]. The main reason for requesting RCCT outside the rules of these clinical decision algorithms is that routine imaging could detect a potential new or progressive injury early, allowing for intervention before lasting neurologic damage occurs [7,8]. However, with recent advances in imaging quality and technology, we now know that CCT scans are not free from ionizing radiation risk [1]. These tomography scans' potential harm is clear, particularly from the perspective of the pediatric population. As a result, a 1-year-old child's lifetime risk of dying from cancer from a single CCT is 10 times higher than the risk of an adult [9]. Radiation exposure also increases the risk of developing cataracts in children and negatively affects cognition in adulthood [9,10].

To the date, we have no clear evidence that the benefits of RCCT outweigh the risks. If RCCT does not provide a clinically meaningful benefit, this implies potential future harm for this patient population. For the adult group, RCCTs have been reported to rarely lead to changes in medical care and treatment in patients whose neurological status does not change [11,12]. A study on children reported that only 4-8% of all CCTs had a traumatic brain injury finding, and only 0.5% of pediatric patients with a Glasgow Coma Scale (GCS) score of 14-15 required neurosurgical intervention [13].

Few studies in pediatric patients with BHI have addressed the routine use of RCCT, and most of them have emphasized the need to change current standards of care [7,14,15]. This study aims to (1) evaluate the characteristics and course of BHI at our center in the pediatric age group and (2) attempt to determine whether routine RCCT produces a change in patient management.

Material and methods

Patients

This 2-year retrospective study was conducted between January 1, 2019, and January 1, 2021, in the city center's ED of a tertiary training and research hospital in Ankara, in Turkey. The medical records of all patients with blunt head injuries aged 18 years and younger (with ICD-10 codes for head injury) were reviewed at the appropriate dates. Patients discharged from ED without CCT after receiving a physical examination (PE), family information, and explanations of emergency conditions were excluded from the study. In addition, patients admitted to neurosurgery, to the intensive care unit or admitted to the operating room for an emergent neurosurgical procedure according to admission PE and trauma characteristics, or initial CCT results were excluded from the study. In our center, the PECARN algorithm was generally used by emergency medicine physicians and neurosurgeons in the evaluation of pediatric blunt head trauma. Patients with a single CCT result, and patients whose admission to ED longer than 24 hours also excluded. The study included patients examined with at least two CCTs during their stay in the ED and whose data were available. Patient age and sex characteristics were recorded, as well as trauma mechanisms, any concomitant injuries, initial CCT pathologies, if there was a significant change in RCCTs, time durations between two CCTs, and discharge and hospitalization or mortality rates. A new or different pathology in RCCTs compared to patients' initial CCT scans was defined as a "significant change" between the two scans. This was generally caused by pathologies such as a new intracranial hemorrhage or contusion, a skull fracture, edema, or an increase in intracranial hemorrhage or a clearly visible non-displaced fracture line compared with the first CCT. It is not the formal policy of the hospital to repeat CCT after admission to determine significant interval changes but clinicians sometimes may order repeat CCT. Informed consent was obtained from participants in the study and the Ethics Committee of Ankara Training and Research Hospital approved the study (decision no: E-21-806, date: 24.11.2021).

Statistical analysis

The Kolmogorov-Smirnov test was used to fit the data to the normal distribution. To compare categorical data, the Chi-square test was performed. For comparisons where the expected numbers in any cell were less than 5, Chi-square analysis with Fisher's exact test was conducted. For data that did not confirm to the normal distribution, the Mann-Whitney U test, a nonparametric test, was performed. For data with a normal distribution, the t-test was performed. Values with a p-value of < 0.05 were considered statistically significant. All analyses were conducted using SPSS for Windows version 18.0 (Chicago, IL, USA).

Results

A total of 110 patients met the inclusion criteria of the study. Six patients were excluded from the study group because the period between the first CCT and the RCCT could not be determined. The remaining 104 patients constituted our patient group. The flow chart of the study group is shown in Figure 1.

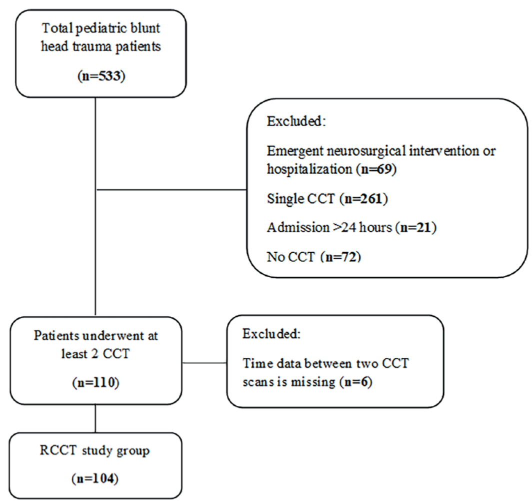

Figure 1 - Flow chart of the study population

The average age of our patients was on 6.2 years (median=4.5 years), and the majority of them were male (n=82, or 78.9%). Patients younger than 10 years old accounted for 74% of the study group (n=77). When the concomitant injury characteristics of the patients were examined, 39.4% (n=41) were found to have at least one concomitant trauma in other organ system. The most common first three associated traumas were trauma to the cervical spine, extremities, and thoracic region. When examining the trauma mechanisms causing BHI, the most common cause was a fall from height (n=84, 80.8%). Motor vehicle accidents, both inside and outside the vehicle, followed the falls (Table 1).

Table 1 Demographics and characteristics of the patients.

Variable	n (%)
Number of patients	104 (100)
Age, mean, SD, in years	6.2 (4.9)
Under 10 years old	77 (74)
Male	82 (78.9)
Concomitant trauma	41 (39.4)
Trauma mechanism, falls	84 (80.8)

Table 2 Initial CCT findings* (*Some patients have more than 1 pathology).

Variable	n (%)
Normal	53 (51)
Skull fracture	28 (26.9)
Soft tissue swelling	17 (16.3)
Contusion	6 (5.8)
Subarachnoid hemorrhage	6 (5.8)
Subdural hemorrhage	5 (4.8)
Intraparenchymal hematoma	3 (2.9)
Epidural hemorrhage	3 (2.9)

CCT, Computerized cranial tomography

Table 3	Significant change on RCCT and prognosis of the patients.
Variable	**n (%)**
Significant change on RCCT (+)/(-)	7/97 (6.7/93.3)
Time duration to RCCT, minute, min-max, SD	247.5 (60-1337, 175)
Prognosis, hospitalization/discharge	35/69 (33.7/66.3)
RCCT, Repeat computerized cranial tomography	

In terms of trauma mechanism, there was no statistically significant difference between patients younger than 10 years of age and patients older than 10 years of age (p=0.123). When the first CCT results of the patients were evaluated, it was revealed that 51% (n=53) of the tomography results were normal. Skull fracture was the most prevalent pathology found in the first CCT scans (n=28, 26.9%). Extracranial soft tissue swelling, contusions, and intracranial hemorrhage were the other most common pathologies (Table 2). Following an average of 247.5 minutes (min:60-max:1337) after the first CCT scans, RCCT scans were performed on the patients. While there were substantial changes in 7 of the RCCTs, there were no significant changes in 97 patients. Only 4 of the 7 patients who had significant changes were taken to the operating room. Of 66.3% (n=69) the total patient group were discharged from the ED (Table 3). Repeat CCT was performed for the third time in 1 patient. This patient was in the discharged group. None of the patients in the study group was died. There were no patients who were referred to another center. All patients with significant changes according to RCCT results also had pathologic findings in their first admission CCT. Repeat CCTs of these 7 patients were not routine and scheduled, but because they clinically deteriorated (vomiting and change in consciousness). None of these patients belonged to the group of patients whose initial CCT was classified as "normal" on admission ($p<0.05$). There was no statistically significant difference in age, sex, or trauma mechanism between patients who had significant changes based on RCCT results and those who did not (Table 4).

Table 4. Patients with significant changes on RCCT scans

	Significant change (-) (n=97)	Significant change (+) (n=7)	p
Initial CCT Normal	53	0	0.005
Initial CCT Abnormal	44	7	
Fall from height	80	4	0.255
MVA, out of vehicle	12	2	
MVA, in vehicle	3	1	
Domestic violence	2	0	
<10 years	72	5	0.585
≥10 years	25	2	
Female	20	2	0.637
Male	77	5	

RCCT, Repeat computerized cranial tomography; MVA, Motor vehicle accident

Discussion

The care of patients with blunt head trauma requires intensive resource use and effort for both the ED and neurosurgical clinics and requires evaluation for general trauma care and neurosurgical intervention. In addition, clinicians who keep the number of CCT scans to a minimum may reduce both the cost of treatment and the potential radiation damage to patients [1]. Routine RCCTs rarely change patient management in patients with stable neurological status and no new complaints or examination findings, according to the adult head injury literature [11,12]. The benefit of repeat imaging has been shown to be minimal, especially in mild traumatic brain injury (GCS score ≥13) [8]. Because of the different trauma mechanisms than in adults, the more difficult collaboration of the physician with the patients, and the greater anxiety, concern, and expectations of the parents and the patient, management of pediatric head injury patients in the ED is more difficult, and imaging techniques may be used more liberally [16,17]. Therefore, the literature on pediatric BHI has also focused on the consequences of the use of ionizing radiation in children and the development of some screening criteria to minimize the number of CCT scans requested to reduce these negative consequences [9,16,17]. However, the evidence on the follow-up of patients with pediatric BHI without CCT, particularly on managing children with pathology at their first CCT, is not clear [1].

Compared to adults, the mechanism of pediatric BHI may be different. While falls [1] and motor vehicle accidents [15] ranked first in various studies, in our study, about 80% of our patients were caused by falls. Given our patient group's relatively young average age (7.9 [1], 10 [15], and 12.5 [7] in some studies in the literature), it is reasonable to conclude that the cause is falling from pushchairs, strollers, cradles, and beds. In our patient group, motor vehicle accidents consisted of a very small proportion of the trauma mechanism. Because very young children cannot yet communicate verbally, the levels of consciousness and neurological examinations in these children are fundamentally different from those of older children and adults. Because of the retrospective nature of our study, we were unable to determine the value of RCCT in the group without verbal communication, but prospective studies may be designed, especially for patients < 2 years old.

In a retrospective 5-year cohort of 95 patients with a head injury, of whom about 70% underwent RCCT, conducted by Hill et al. [1], the authors reported that no significant change in approximately 2/3 of the patients who underwent RCCT. According to the authors, RCCT changed the management of only one patient (the need for surgical intervention emerged), but this was already apparent from the patient's neurological examination [1]. The authors reported RCCT scans should be taken if new or worsening neurological symptoms or GCS score changes were present [1]. Similarly, in the study by Aziz et al. [7], in which they examined RCCT imaging of 191 patients, the authors concluded that routine RCCT for mild to moderate traumatic brain injury did not cause any management change (in terms of neurosurgical intervention). Repeat neurological examinations have been reported to be a safe and cost-effective alternative to routine RCCTs especially in pediatric BHI patients with a GCS score of 8 and above [1,7]. Howe et al. [2] also do not recommend routine use of RCCT in pediatric patients with BHI with a GCS score of 14 and above without clinical deterioration. The authors noted that in their study, which examined the RCCT of 106 patients, only 7 patients developed worsening changes in re-images, and only 2 of them required surgery [2]. In the 10-year retrospective cohort of Bata et al. [15], in which they evaluated the routine RCCT imaging of 36 patients, the authors reported that the RCCT scans did not reveal the need for craniotomy in any of the patients and made the decision for longer-term ICP monitoring in only 2 patients. Only 7 of the 104 patients who underwent RCCT in our study had a significant radiological change, and more importantly, these 7 patients had already pathology in the first CCT. No new pathology occurred in the RCCT of any patient who did not have an acute pathology on admission CCT. This is a statistically significant result. Neurosurgical intervention was required in only 4 of these 7 patients. Therefore, new CCT scans enabled a change in patient management in only 4 of 104 RCCT patients. Considering that the population of BHI included 533 patients at first, we consider this a relatively low rate. The fact that about half of our study group had "normal" CCTs at initial admission and about two-thirds of them were discharged from ED may suggest that our patient group is mild to moderate head injury. Furthermore, as a limitation, the fact that we did not record the GCS scores of patients makes it difficult for us to make a judgment on this issue. In our patient group, intracranial hemorrhages are also generally less frequent than described in the literature. This situation may justify the criticism that RCCT in patients with mild head injuries obviously does not lead to a significant change in patient management, but it remains to be discussed why such an intensive RCCT scans were used in such a mildly traumatized group. Other authors also reported RCCT scans in pediatric head trauma do not provide evidence for changes in patient management [18,19]. Again, in a study of 50 pediatric patients with mild to moderate head trauma under 2 years of age, it was investigated whether RCCT affected clinical management and treatment and the authors reported that RCCT did not change patient management without clinical deterioration [20]. On the other hand, there are publications suggesting that RCCT in infants may provide more significant changes, but the authors recommend further validation of this study with a larger number of studies [21].

In some studies in the literature [1,7,15], the meantime for the control image series after the first CCT is 12, 21, and 24 hours, respectively, whereas, in our study, it was about 4 hours (247.5 minutes). We consider that a significant change will not occur in such a short time, or even if it does, it may not yet have a chance to being visible on CCT. In this regard, we believe that an approach like routine RCCT 4-6 hours after the first imaging in the pediatric or adult head injury patients, which has become a classic in our ED and many hospitals in our country, may be changed.

Limitations

We would be able to present clearer data regarding whether RCCT has varied different value for these different groups if we could record the GCS scores of the patients in the study group and divide them into mild-moderate and severe head injury. This is due to data loss, and retrospective nature of the study. So we may have the opportunity to talk about a group that would benefit greatly from RCCT scan or a group that should not have RCCT at all. A prospective study may provide stronger control for these variables. Second, hemorrhage volumes of patients on CCT scans, whether there was an increase in these volumes, length of hospital stay of the patients, number of patients required mechanical ventilation (if any), and length of intensive care unit stay could not be evaluated because of the loss of retrospective data. We consider that these data are also important for such a group. Finally, our data was dependent to hospital data recording systems. We also consider that data on what happens in these patients during follow-up is also important. Further studies may be needed to determine whether a particular type or size of intracranial hemorrhage or skull fracture requires special control imaging.

Conclusion

According to our results, routine RCCT for a BHI in pediatrics does not result in a significant change in patient management. When the entire patient population is considered, the rate of significant change noted in these scans is quite low. Compared to the literature, the duration between repeating CCT is relatively short, which may prevent relevant changes from being reflected in the imaging scans. We believe that repeat CCT decisions of the clinicians deserve a careful consideration in the pediatric population in terms of high radiation exposure. Routine RCCT may be applied to patients more selectively and that well-designed prospective studies are required to determine the time and indications for RCCT in pediatric BHI.

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References

1. Hill EP, Stiles PJ, Reyes J, Nold RJ, Helmer SD, Haan JM. Repeat head imaging in blunt pediatric trauma patients: Is it necessary? *J Trauma Acute Care Surg*. 2017;82(5):896-900. https://doi.org/10.1097/TA.0000000000001406
2. Howe J, Fitzpatrick CM, Lakam DR, Gleisner A, Vane DW. Routine repeat brain computed tomography in all children with mild traumatic brain injury may result in unnecessary radiation exposure. *J Trauma Acute Care Surg.* 2014;76(2):292-6. https://doi.org/10.1097/TA.0000000000000119
3. da Silva PS, Reis ME, Aguiar VE. Value of repeat cranial computed tomography in pediatric patients sustaining moderate to severe traumatic brain injury. J Trauma. 2008;65(6):1293-7. https://doi.org/10.1097/TA.0b013e318156866c
4. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD Jr, et al. Pediatric Emergency Care Applied Research Network (PECARN). 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. https://doi.org/10.1016/S0140-6736(09)61558-0
5. Dunning J, Daly JP, Lomas JP, Lecky F, Batchelor J, Mackway-Jones K. Children's head injury algorithm for the prediction of important clinical events study group. 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. https://doi.org/10.1136/adc.2005.083980
6. Osmond MH, Klassen TP, Wells GA, Correll R, et al. Pediatric Emergency Research Canada (PERC) Head Injury Study Group. CATCH: a clinical decision rule for the use of computed tomography in children with minor head injury. *CMAJ*. 2010;182(4):341-8. https://doi.org/10.1503/cmaj.091421
7. Aziz H, Rhee P, Pandit V, Ibrahim-Zada I, et al. Mild and moderate pediatric traumatic brain injury: replace routine repeat head computed tomography with neurologic examination. *J Trauma Acute Care Surg*. 2013;75(4):550-4. https://doi.org/10.1097/TA.0b013e3182a53a77

8. Brown CV, Zada G, Salim A, Inaba K, et al. Indications for routine repeat head computed tomography (CT) stratified by severity of traumatic brain injury. *J Trauma.* 2007;62(6):1339-45. https://doi.org/10.1097/TA.0b013e318054e25a
9. Brenner D, Elliston C, Hall E, Berdon W. Estimated risks of radiation-induced fatal cancer from pediatric CT. *AJR Am J Roentgenol*. 2001;176(2):289-96. https://doi.org/10.2214/ajr.176.2.1760289
10. Hall P, Adami HO, Trichopoulos D, Pedersen NL, et al. Effect of low doses of ionising radiation in infancy on cognitive function in adulthood: Swedish population based cohort study. *BMJ*. 2004;328(7430):19. https://doi.org/10.1136/bmj.328.7430.19
11. Stippler M, Smith C, McLean AR, Carlson A, et al. Utility of routine follow-up head CT scanning after mild traumatic brain injury: a systematic review of the literature. *Emerg Med J*. 2012;29(7):528-32. https://doi.org/10.1136/emermed-2011-200162
12. Figg RE, Burry TS, Vander Kolk WE. Clinical efficacy of serial computed tomographic scanning in severe closed head injury patients. J Trauma. 2003;55(6):1061-4. https://doi.org/10.1097/01.TA.0000096712.90133.5C
13. Schnadower D, Vazquez H, Lee J, Dayan P, Roskind CG. Controversies in the evaluation and management of minor blunt head trauma in children. *Curr Opin Pediatr.* 2007;19(3):258-64. https://doi.org/10.1097/MOP.0b013e3281084e85
14. Hollingworth W, Vavilala MS, Jarvik JG, Chaudhry S, et al. The use of repeated head computed tomography in pediatric blunt head trauma: factors predicting new and worsening brain injury. *Pediatr Crit Care Med.* 2007;8(4):348-56. https://doi.org/10.1097/01.PCC.0000270837.66217.3B
15. Bata SC, Yung M. Role of routine repeat head imaging in paediatric traumatic brain injury. *ANZ J Surg.* 2014;84(6):438-41. https://doi.org/10.1111/ans.12582
16. Almenawer SA, Bogza I, Yarascavitch B, Sne N, et al. The value of scheduled repeat cranial computed tomography after mild head injury: single-center series and meta-analysis. *Neurosurgery*. 2013;72(1):56-64. https://doi.org/10.1227/NEU.0b013e318276f899
17. 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. *Arch Dis Child*. 2014;99(5):427-31. https://doi.org/10.1136/archdischild-2013-305004
18. AbdelFattah KR, Eastman AL, Aldy KN, Wolf SE, et al. A prospective evaluation of the use of routine repeat cranial CT scans in patients with intracranial hemorrhage and GCS score of 13 to 15. *J Trauma Acute Care Surg*. 2012;73(3):685-8. https://doi.org/10.1097/TA.0b013e318265ccd9
19. Joseph B, Aziz H, Pandit V, Kulvatunyou N, et al. A three-year prospective study of repeat head computed tomography in patients with traumatic brain injury. *J Am Coll Surg*. 2014;219(1):45-51. https://doi.org/10.1016/j.jamcollsurg.2013.12.062
20. Utsumi S, Ohnishi S, Amagasa S, Sasaki R, Uematsu S, Kubota M. Role of Routine Repeat Head CT for Pediatric Patients under 2 Years Old with Mild-to-moderate Traumatic Brain Injury. *Neurol Med Chir (Tokyo).* 2022;62(3):133-139. https://doi.org/10.2176/nmc.oa.2021-0221
21. Engel EP, Bitter B, Reyes J, Grundmeyer R, Helmer SD, Haan JM. Should Infants with Blunt Traumatic Brain Injuries and Intracranial Hemorrhage Have Routine Repeat Imaging? *Kans J Med.* 2023;16:117-120. https://doi.org/10.17161/kjm.vol16.19209