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Role of Routine Repeat Head CT for Pediatric Patients under 2 Years Old with Mild-to-moderate Traumatic Brain Injury

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Abstract

Repeat head computed tomography (RHCT) is common and routine for pediatric traumatic brain injury (TBI) patients. In mild (Glasgow Coma Scale; GCS 13–15) to moderate (GCS 9–12) TBI, recent studies have shown that RHCT without clinical deterioration does not alter management. However, the effectiveness of routine RHCT for pediatric TBI patients under 2 years has not been investigated. This study aims to investigate whether routine RHCT changes management in mild-to-moderate TBI patients under 2 years. We performed a retrospective review at the emergency department of the National Center for Child Health and Development between January 2015 and December 2019. Mild-to-moderate TBI patients under 2 years with an acute intracranial injury on initial head CT scan and receiving follow-up CT scans were included. Mechanism, severity of TBI, indication for RHCT, and their findings were listed. Study outcome was intervention based on the findings of RHCT. Intervention was defined as intubation, ICP monitor placement, or neurosurgery. We identified 50 patients who met inclusion criteria and most patients (48/50) had mild TBI. The most common mechanism was 'fall' (68%). Almost all RHCT was routine and the overall incidence of radiographic progression on RHCT was 12%. RHCT without clinical deterioration did not lead to intervention, although one patient with moderate TBI required intervention due to radiographic progression with clinical symptoms. Our study showed that routine RHCT without clinical deterioration for mild TBI patients under 2 years may not alter clinical management. We suggest that RHCT be considered when there is clinical deterioration such as decrease in GCS.

Keywords: traumatic brain injury, pediatric patients under 2 years old, routine, repeat head computed tomography, clinical deterioration

Introduction

Traumatic brain injury (TBI) is a leading cause of death and disability in children worldwide. Head computed tomography (CT) is the gold standard for the evaluation of pediatric TBI.[1,2] In patients younger than 2 years old, clinical assessment is difficult due to lack of language skills and infants with intracranial injuries are frequently asymptomatic.[3,4] When an injury is identified, repeat head computed tomography (RHCT) is common and routine owing to concerns about progression of injury.[5]

Routine RHCT can identify new or worsening TBI, although it is an expensive diagnostic modality and exposes the child to risks, including radiation exposure.[6] Opinion is divided on the role of routine RHCT for clinical management in pediatric TBI patients. Routine RHCT is recommended due to inability to clinically assess neurological status in severe (GCS <8) TBI patients.[7,8] In mild (GCS 13–15) to moderate (GCS 9–12) TBI, recent studies have reported that RHCT in the absence of clinical deterioration does not alter management.[9–13]

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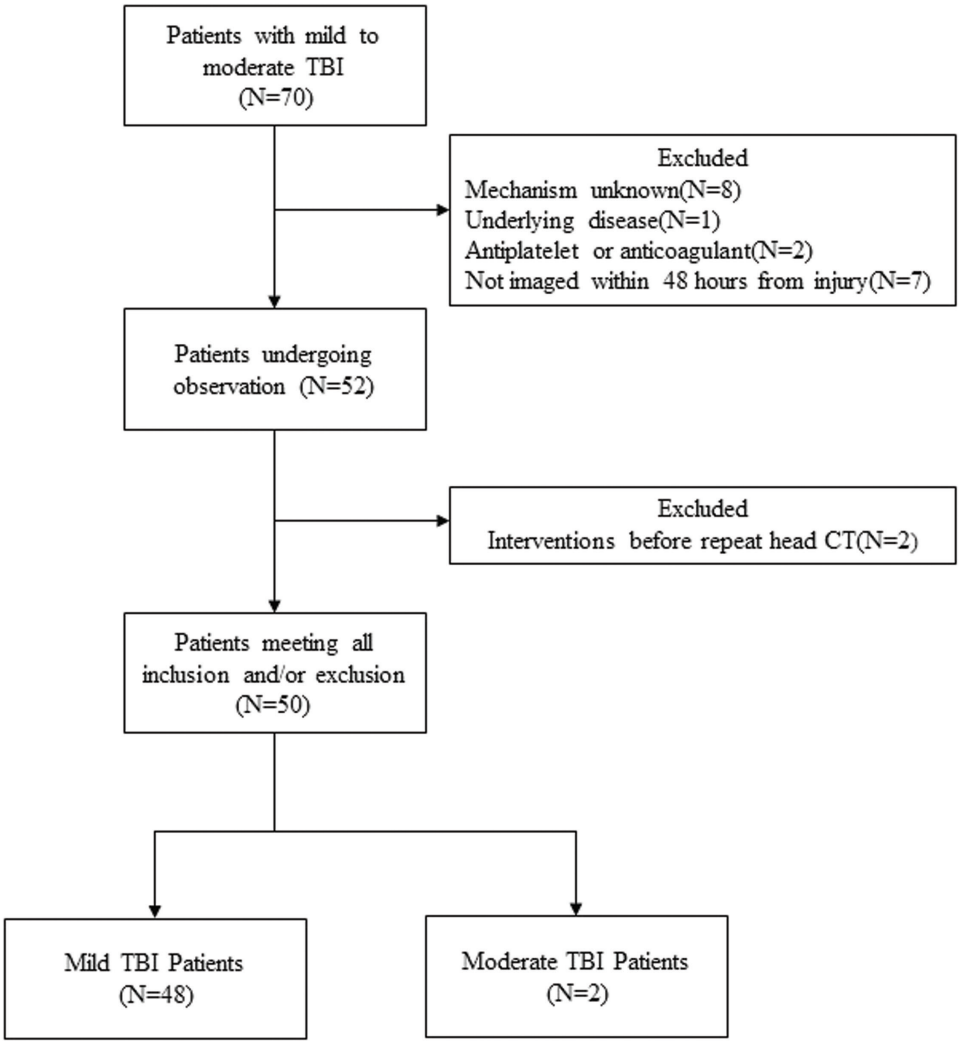

Fig. 1 Diagram of subject inclusion for analysis.

However, few studies have examined the effectiveness of routine RHCT for pediatric TBI patients,[12,13] particularly those under 2 years old. To investigate whether routine RHCT in mild-to-moderate TBI changes management, we analyzed pediatric TBI patients under 2 years old.

Materials and Methods

We performed a retrospective review at the emergency department of the National Center for Child Health and Development (NCCHD), from January 2015 to December 2019. Inclusion criteria were as follows: aged 0–23 months with mild-to-moderate TBI, admitted with an acute intracranial injury on initial head CT scan, and receiving follow-up CT scans during hospitalization. The indications for initial head CT in head trauma at our hospital are as follows: all patients with Glasgow Coma Scale (GCS) of 13 or less are eligible, patients with GCS of 14 or more are eligible according to the PECARN criteria.[14] Patients were excluded if they met any of the following criteria: (i) patients who were not imaged within 48 hours from injury, (ii) injury mechanism unknown, (iii) surgical interventions or intensive care, including intubation and intracranial pressure (ICP) monitoring, before RHCT, (iv) torso injury, (v) underlying diseases, that is, systemic bone disease, coagulation disorder, cerebral palsy, or mental retardation, and (vi) taking antiplatelet agents or anticoagulant agents.

Data collected included patient demographics, mechanism of trauma, head Abbreviated Injury Scale (AIS), Injury Severity Score (ISS), GCS, severity of TBI based on the initial GCS (mild, 13–15; moderate, 9–12; severe, 3–8), neurological examination on presentation, initial head CT scan findings, time to initial head CT after injury, reasons and results for

Table 1 Demographic characteristics of the 50 patients included in this study

	No. of patients (%)
Median age, month (IQR)	3 (1–8)
Males	33 (66%)
Injury type	
Fall	34 (68%)
Fall from sitting or standing position	14 (28%)
Other	2 (4%)
Severity of traumatic brain injury	
Mild	48 (96%)
Moderate	2 (4%)
Median ISS (IQR)	16 (10–16)
Median head AIS (IQR)	3 (3–4)
Symptoms	
Not doing well	14 (28%)
Vomiting	10 (20%)
Seizure	4 (8%)
Focal neurologic deficit	2 (4%)
Conjugate deviation	2 (4%)
Motor deficit	1 (2%)
No symptom	30 (60%)
Median time from trauma to initial CT scan, hours (IQR)	3 (2–4.5)
Type of initial CT scan findings, n (%)	
EDH	20 (40%)
SDH	19 (38%)
SAH	15 (30%)
IVH	1 (2%)
Contusion	1 (2%)
Fracture n (%)	36 (72%)
Midline shift n (%)	4 (8%)

AIS: Abbreviated Injury Scale, CT: computed tomography, EDH: Epidural hematoma, ISS: Injury Severity Score, SDH: subdural hematoma, SAH: subarachnoid hemorrhage, IVH: intraventricular hemorrhage.

primary and secondary RHCT, time to RHCT, number of repeat scans during hospitalization, interventions required (intubation, ICP monitor placement, neurosurgery) after RHCT, length of pediatric intensive care unit (PICU) and hospital stay, mortality, and Pediatric Cerebral Performance Category (PCPC).

Our primary outcome measurement was intervention based on the findings of RHCT. Intervention was defined as intubation, ICP monitor placement, or neurosurgery.

Intubation was performed in following situation: Decreasing level of Consciousness (GCS <8) or rapidly falling, signs of respiratory failure, and hemodynamic instability.[15]

Decreased consciousness level (GCS <8) was the basic criteria for considering ICP monitor placement[16]; however, the final decision was made by neurosurgeons and intensivists.

Clinical deterioration was defined as a decrease in GCS score, vomiting, or a new onset localizing sign.[3,12,13] RHCT was categorized as (i) routine or (ii) based on clinical deterioration. Routine RHCT was defined as being ordered for the following 24 hours irrespective of changes in the patient's clinical condition.[13,17] Primary RHCT was defined as after initial head CT and secondary RHCT was defined as after primary RHCT. All imaging findings were assessed by radiologists. RHCT results were

Table 2 Indications for primary RHCT (N = 50) and secondary RHCT (N = 16), findings and management

	Primary RHCT	Secondary RHCT
Median time to RHCT, hours (IQR)	9.4 (3.5–14.4)*	15.8 (9–18.1)†
Indication for RHCT, n (%)		
Monitor progression	50 (100%)	15 (94%)
Decrease in GCS	0 (0%)	1 (6%)
Findings on RHCT, n (%)		
Stable	45 (90%)	14 (88%)
Worse	5 (10%)	2 (12%)
Management, n (%)		
Conservative	50 (100%)	16 (100%)

*Median time to primary RHCT from initial head CT. †Median time to secondary RHCT from primary RHCT. GCS: Glasgow Coma Scale, RHCT: repeat head computed tomography.

classified as either "stable" or "worse". Lesions that were unchanged or improved were defined as "stable", whereas an increase in the size of the initial hemorrhage or a new hemorrhage previously not evident on the initial head CT was labeled as "worse". Hematoma thickness was calculated at the maximum. Injury type was categorized as "fall", "fall from sitting or standing position", and "other". PCPC was defined as evaluated after 2 months. Because our hospital is not a trauma center, most TBI patients in our institution are mild and TBI patients are normally followed up after 1 or 2 months.

This study was approved by the institutional review board at NCCHD.

Results

As noted in Fig. 1, 70 patients presented to the emergency department with traumatic intracranial injury on imaging. After applying exclusion criteria, 50 patients met inclusion criteria (Table 1). Of these, 48 patients had mild and 2 patients had moderate TBI. The median age was 3 months (interquartile range: 1–8) There were 33 boys (66%) and 17 girls (34%). The most common mechanism was "fall" (68%). At the time of admission, 14 patients (28%) were noted as "not doing well", 10 patients (20%) were noted as "vomiting", and 2 patients (4%) was noted as "neurological finding, such as paralysis or conjugate deviation". There were also four patients (8%) who were noted as "seizure before being taken to the hospital". A total of 30 patients (60%) were asymptomatic. The median head AIS was 3 (3–4) and ISS was 16 (10–16). The median time to initial head CT from injury was 3 hours (2–4.5). Epidural hematoma was the most common injury (seen in 40%), followed by subdural hematoma 38%. A total of 36 (72%) patients had skull fractures and 4 (8%) patients had midline shift.

Primary RHCT and secondary RHCT

Table 2 highlights the indications for RHCT, findings, and management after repeat imaging. The median time to primary RHCT was 9.4 hours (3.5–14.4). All primary RHCT was routine to monitor hemorrhage progression in the absence of any changes in relevant symptoms or clinical examination; radiographic progression was seen in 5 patients (10%). However, none of the patients required intervention after primary RHCT. With regard to secondary RHCT, a total of 32% of the patients (16/50) received secondary RHCT and 2 (12%) showed evidence of radiographic progression. A total of 15 patients (94%) received RHCT as routine, whereas one patient had an RHCT owing to neurological deterioration. None of the patients required intervention after secondary RHCT. Figure 2 summarizes findings regarding RHCT and the management after RHCT. Finally, one patient required intervention due to radiographic progression with clinical deterioration.

Clinical outcomes

Descriptions of the hospital course and PCPC for the 50 included patients are shown in Table 3. A total of 49 (98%) patients were treated with conservative management, whereas one patient underwent intervention. The median total number of CTs was 2 (2–3). All patients were admitted to the PICU with median stay of 2 days (1.3–4); the median length of hospital stay was 9 days (7–11). No patients died during hospital admission. The most common (94%) PCPC was grade 1.

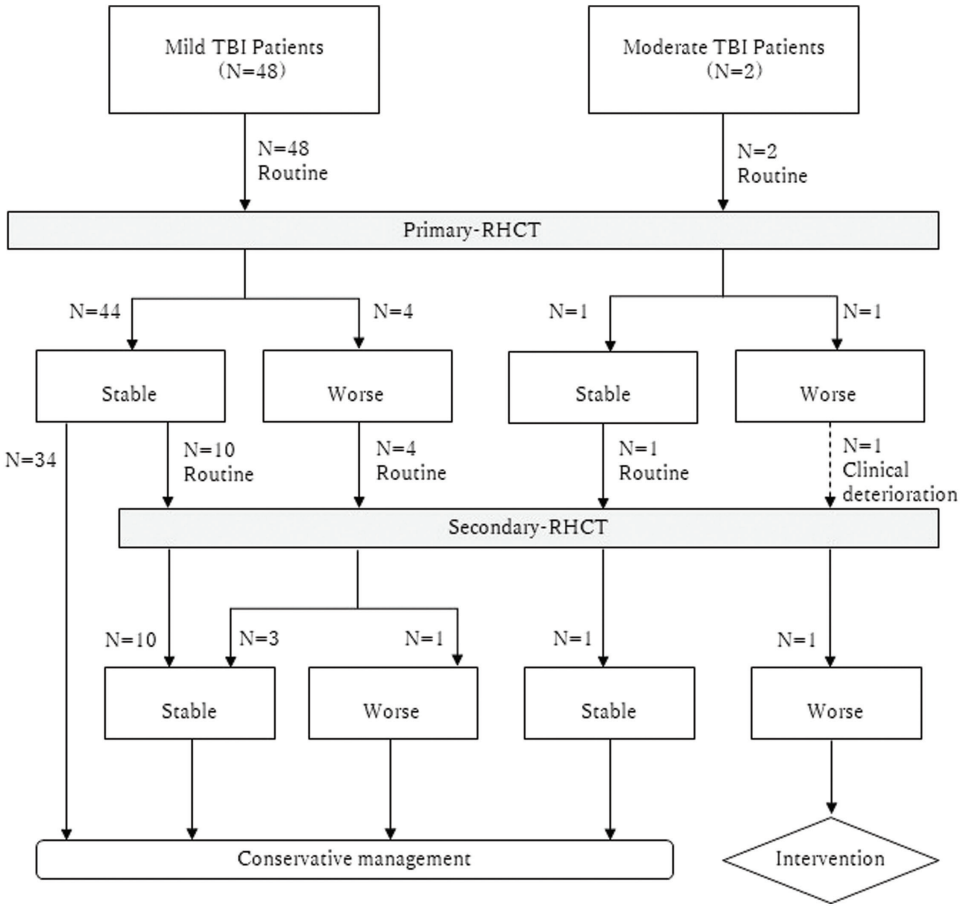

Fig. 2 50 children under 2 years old of mild and moderate TBI patients. TBI: traumatic brain injury.

Discussion

We retrospectively reviewed a group of patients under 2 years old with mild-to-moderate TBI. In this study, routine RHCT without clinical deterioration did not change management. Few mild TBI patients had radiographic progression in routine RHCT. These findings suggest that routine RHCT may not be recommended for mild pediatric TBI patients under 2 years without clinical progression.

There are no standards as to when to order a routine RHCT in pediatric TBI patients. In adults, many studies have shown that routine RHCT in neurologically stable patients may not be necessary.[9–11] For the past several years, there are some reports of RHCT in mild-to-moderate pediatric TBI patients. Aziz et al. found that RHCT did not change management in children 2–18 years of age with mild or moderate head injuries and that follow-up neurological examination can be an alternative to RHCT.[12] Hill et al. also argue that following changes in neurological symptoms and GCS score with the TBI patient under 18 years can be a selective alternative approach for repeating head CT.[13] From these studies, for pediatric TBI patients, neurological examination is very important and can reduce RHCT administration.

In our study, there were no mild TBI patients who developed clinical deterioration, decrease in GCS, or neurological abnormality, and required intervention. Previous studies have shown that little clinical worsening was observed in mild TBI groups and almost all RHCT was performed as routine; therefore, intervention was rarely required for mild TBI patients.[12,18] Our data are in concordance with these studies. Only one patient with moderate TBI showed decrease in GCS, which led to intubation and ICP monitor placement. Several studies have reported that decrease in GCS did change management and required intervention as surgery or ICP monitor placement in TBI groups. Decrease in GCS may lead to change in management as per previous studies.[12,13] Based on our study, routine RHCT without clinical deterioration for mild TBI patients under 2 years old may not alter clinical management and RHCT should be considered when there are clinical indications such as decrease in GCS.

Table 3 Hospital course and outcome of included patients

Management, n (%)	
Conservative	49 (98%)
Intervention (ICP monitor, intubation)	1 (2%)
Median total number of CT scans, n (IQR)	2 (2–3)
Median length of PICU stay, days (IQR)	2 (1.3–4)
Median length of hospital stay, days (IQR)	9 (7–11)
Death, n (%)	0 (0%)
PCPC, n (%)	
Grade 1	48 (96%)
Grade 2	1 (2%)
NA	1 (2%)

ICP: intracranial pressure, PCPC: Pediatric Cerebral Performance Category.

The overall incidence of progression on RHCT was 12%; however, no patients required intervention. As to secondary RHCT, 16 patients (32%) received it. One patient had clinical deterioration, whereas another 15 patients received routine RHCT. As in Fig. 2, 4 patients (27%) received secondary RHCT due to progression in primary RHCT. However, the reasons why the other 11 patients received secondary RHCT as routine were unknown. Although two patients (4%) had radiographic progression, they did not require subsequent intervention. Recent studies have found that 6–20% of patients show imaging progression in low severity TBI.[19–21] Almost all our patients had mild TBI and our findings were consistent with previous studies. Routine RHCT did not change management in our study.

To date, pediatric RHCT studies have targeted older patients and few reports have focused on those under 2 years old. Patients under 2 years cannot verbally communicate and follow instructions for the medical examination, so it is difficult to evaluate neurological status as their GCS score.[3,4] Besides that, patients under 2 years can easily become irritable and GCS scores may not be perfect for causes other than brain dysfunction. However, Borgialli et al. found that GCS may be useful to identify clinically important TBIs for pediatric TBI patients under 2 years, similarly to older children.[22]

Recent studies have already reported that routine RHCT is not recommended for mild-to-moderate adult and relatively older pediatric TBI patients without neurological deterioration.[9–13] However, whether GCS score and the age-equivalent neurological evaluation are effective for the RHCT in pediatric TBI under 2 years old has not been examined previously. Our study showed that routine RHCT without neurological deterioration did not change management and only one patient required intervention due to neurological abnormality. One feature of our study is that it showed the possibility that GCS and neurological assessment can be used as a reference for the necessity of RHCT, even in patients under 2 years of age, and could reduce radiation exposure for the TBI patients under 2 years.

There were very few moderate TBI patients in our study. This result is similar to previous studies that have shown the number of moderate TBI patients was smaller compared to the number of mild and severe TBI patients.[12,14] In addition, as our hospital is not a trauma center, it is understandable that the severity of TBI was low. It is difficult to say whether the routine RHCT for moderate pediatric TBI patients under 2 years changed management or not.

This study has several limitations. First, it is a retrospective study. Because of its retrospective nature, a protocol for RHCT was not decided and reliance on medical records that may be deficient in important information for decision-making as to whether RHCT is performed or not. Besides that, this research was done in a single pediatric hospital over a 5-year period, and our practice may not reflect practice in other centers. In addition, it is difficult to know what happens to these patients in the long term (e.g., PCPC at 6 months or more afterwards) due to low severity of TBI and being limited by the data available in the hospital records. Ideally, we would like to know what happens to these patients in the long term to differentiate whether routine RHCT changes outcomes or not. Finally, the present study could not develop criteria for detecting patients who need RHCT due to the small number of eligible cases and the low incidence of events. Further large-scale studies are needed to develop criteria for detecting patients who need RHCT, such as the criteria for detecting clinically important TBI in children with head trauma.[23]

Our study showed that routine RHCT may not alter management in mild pediatric TBI patients under 2 years. We suggest that RHCT be considered when there are clinical indications.

Conflicts of Interest Disclosure

The authors report no conflicts of interest concerning this study.

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