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Factors influencing emergency department care of young children at-risk for clinically important traumatic brain injury

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ABSTRACT

Objectives: Care decisions for young children presenting to the emergency department (ED) with head injury are often challenging (e.g. whether to obtain neuroimaging). We sought to identify factors associated with acute management of children at-risk for clinically important traumatic brain injury (ciTBI) and describe symptom management.

Methods: Observational evaluation of children, ages 0–4 years, presenting to a pediatric ED following minor head injury. Children with ≥1 risk element per the Pediatric Emergency Care Academic Research Network's decision rule were deemed "at-risk" for ciTBI. Clinician surveys regarding their initial clinical management were used to identify three care groups. Nonparametric tests analyzed group differences and logistic regression investigated associations of putative high-risk factors with neuroimaging.

Results: Of 104 children enrolled: (i) 30 underwent neuroimaging, (ii) 59 were observed, and (iii) 15 were discharged following the clinician's initial patient exam. Children with a non-frontal scalp hematoma were more likely to receive immediate neuroimaging and children not acting like themselves per caregiver report were more likely to be initially observed, relative to the other care groups ($p \leq 0.01$). Among high-risk factors, altered mental status (OR 5.12, 95% CI 1.8–21.1), presence of ≥3 risk elements of the decision rule (OR 3.5, 95% CI 1.2–10.6), unclear skull fracture on exam (OR 31.3, 95% CI 5.4–593.8), and age < 3 months (OR 5.3, 95% CI 1.5–21.9) were associated with neuroimaging. No child had ciTBI. TBI symptoms (e.g. vomiting) were infrequently treated.

Conclusions: ED management varied for young children with similar risk stratification. Investigation of how age in concert with specific risk factors influences medical decision making would advance evidenced-based care.

1. Introduction

Children ages 0–4 years have the highest annual rate of emergency department (ED) visits for traumatic brain injury (TBI) [1]. Although intracranial injury rates are low (<10%) in children with mild TBI (i.e. Glasgow Coma Scale (GCS) score 14–15), the decision to obtain neuroimaging in this age group is complicated by limited communicative skills [2,3]. The Pediatric Emergency Care Applied Research Network's (PECARN) decision rules (Table 1) have excellent sensitivity in identifying children at very low risk (<0.05%) for clinically important TBI (ciTBI) who do not require neuroimaging. For children stratified as intermediate (~1%) or elevated (~4%) risk for ciTBI, either a clinical observation period or immediate head CT is recommended depending on which decision-rule elements are present [4]. Research supports observation as a safe management option, even for children with PECARN elements that are associated with "elevated" risk for ciTBI (Table 1) [5,6]. Despite increasing implementation of observation periods across EDs, [7,8] there continues to be substantial variation in head CT use [9,10]. Given an increased risk for radiation-associated malignancy, [11,12] judicious head CT use during early childhood is essential, yet it is unclear why clinicians might hesitate to initially observe. Thus, we need to understand influences on the decision to obtain emergent CT and forego observation, particularly in young children who are unable to articulate symptoms.

This study examined associations of individual and injury-level factors with a clinician's decision to obtain neuroimaging, observe, or

Abbreviations: ciTBI, clinically important traumatic brain injury; PECARN, Pediatric Emergency Care Academic Research Network.

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Table 1
PECARN minor head injury clinical decision rules for risk of clinically important traumatic brain injury (ciTBI).

Risk stratification	Age < 2 years of age	Age ≥ 2 years of age
At-risk		
Elevated risk (~4%)	Altered mental status[a]	Altered mental status[a]
	Palpable skull fracture or unclear exam[b]	Signs of basilar skull fracture
Intermediate risk (~0.6–1.6%)	Severe injury mechanism[c]	Severe injury mechanism[c]
	Loss of consciousness >5 s	Any loss of consciousness
	Non-frontal scalp hematoma	Vomiting
	Not acting normally per parent	Severe headache
Very low risk (<0.05%)	None of the above	None of the above

PECARN: Pediatric Emergency Care Applied Research Network.
ciTBI: death from traumatic brain injury, neurosurgery, intubation for >24 h for traumatic brain injury or hospital admission for ≥ 2 nights for persistent symptoms associated with traumatic brain injury on computed tomography (defined as: intracranial hemorrhage or contusion, cerebral edema, traumatic infarction, diffuse axonal injury, shearing injury, sigmoid sinus thrombosis, midline shift of intracranial contents or signs of brain herniation, diastasis of the skull, pneumocephalus, skull fracture depressed by at least the width of the table of the skull).
[a] Altered mental status was identified if the emergency department provider identified the child having a Glasgow Coma Scale of 14, agitation, sleepiness, slowed response, or repetitive questioning.
[b] Palpable skull fracture or unclear if fracture is present due the degree of swelling or distortion of the scalp.
[c] Severe mechanism included motor vehicle crash with patient ejection, death of another passenger or rollover, pedestrian or bicyclist without helmet struck by motorized vehicle, head struck by high impact object, or falls >3 ft for children <2 years of age and >5 ft for children ≥2 years.

discharge a child after their primary assessment among children ages 0–4 years deemed at-risk for ciTBI (i.e. ≥1 element of the PECARN rule). We also investigated the association between putative high-risk factors for ciTBI and immediate neuroimaging. Secondary objectives were to describe factors clinicians perceived to have influenced their decision to obtain neuroimaging and to delineate medications delivered to symptomatic children. We sought to characterize care delivered to this commonly encountered, yet diagnostically challenging, population of young children at-risk for ciTBI with the goal of highlighting opportunities to improve ED care.

2. Materials and methods

2.1. Study design

This subanalysis of a prospective study characterizes medical decision making and ED care of children, ages 0–4 years, at-risk for ciTBI. Study methods and reports of parental understanding of ED care for this cohort have been previously detailed [13].

At enrollment, the ED clinician completed a survey about care provided and influences on medical decision making. The initial question, "Which of the following best describes your decision regarding a CT order and its timing in this case?", included responses: "1, A decision has not yet been made, but will be after a period of observation | 2, A decision to order a CT was made immediately after initial evaluation | 3, A decision to order a CT was made after a period of observation | 4, A decision to NOT order a CT was made immediately after initial evaluation | 5, A decision to NOT order a CT was made after a period of observation". Branch logic based on initial response guided subsequent queries about care provided (e.g. pain assessment, evaluating food/drink tolerance). Potential influences on the decision to obtain neuroimaging (e.g. child's age, parental preference) were ranked as "1, No influence | 2, Slight influence | 3, Moderate influence | 4, Strong influence | 5, Not a factor in this case", with ratings of "moderate" and "strong" constituting "major" influences on care.

Care practices extracted from the medical record included pain and antiemetic medications and pain assessments based on the Face, Legs, Activity, Cry, Consolability (FLACC) scale [14]. This study was IRB approved and informed consent was obtained from participants.

2.2. Statistical analysis

Patient groups were created based on initial care per clinician report: 1) Immediate CT, 2) Immediate observation (i.e. the child was placed into observation before the decision to obtain a CT was made), and 3) Immediate discharge. Kruskal–Wallis and Fisher's exact tests were performed to evaluate for group differences in demographics, injury descriptors (e.g. time between injury and ED arrival), and PECARN rule elements. Clinician training was grouped into physician with pediatric emergency medicine (PEM) board certification, physician with pediatric board certification, and Advanced Practice Registered Nurse (APRN). We used logistic regression to investigate associations between factors identified as high-risk and the child's odds of receiving an immediate CT. High-risk factors included: altered mental status per clinician, palpable/unclear skull fracture on exam [4], presence of ≥3 intermediate-risk PECARN elements (Table 1) [7], and age < 3 months old [15]. Descriptive statistics identified factors that clinicians reported as influencing their decision to obtain neuroimaging, as well as characterized frequencies of symptomatic treatments. All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

3. Results

Between December 2014 and December 2015, 104 eligible participants provided consent. An additional seven patients declined and 23 potentially eligible participants were not approached due to research coordinator time constraints. There were no significant demographic differences between enrolled and declined/missed groups.

Per clinician report, 30 children underwent immediate neuroimaging, 59 were placed into observation, and 15 were discharged home after their initial exam. Most participating clinicians were PEM certified physicians ($n = 75$, 72%), and clinician training did not significantly vary across groups. The average (standard deviation) time elapsed between injury and ED arrival was 1.3 (1.3) hours and did not differ significantly between groups. Most children were injured due to a fall from elevation (60%) or down stairs (14%). Vomiting and non-frontal scalp hematoma were the most commonly reported PECARN rule elements (Table 2). Of the 14 children with altered mental status, 10 (71%) had a GCS of 14, and 6 (43%) were noted to be somnolent or slow to respond.

In separate univariate logistic regression models investigating the association between high-risk factors and receipt of immediate neuroimaging: altered mental status, presence of ≥3 PECARN intermediate risk elements, palpable/unclear skull fracture on exam, and age < 3 months were all associated ($p < 0.05$) with immediate neuroimaging (Table 3). Among the 30 children who received immediate neuroimaging, seven had isolated skull fractures and five had intracranial injury. All children with intracranial injury were <6 months old, had a GCS of 15, and a severe mechanism of injury (i.e. fall >3 ft). Five additional children underwent neuroimaging following observation due to new or worsening symptoms (e.g. developed vomiting), of which two had isolated skull fractures. No child had ciTBI.

Fig. 1 displays factors that influenced clinicians to obtain a CT, regardless if it was obtained before or after a period of observation. Age was cited as a major influence in 24 cases, of which all were ≤2 years old and 7 (29%) were <3 months old. Of the 23 cases in which presence of scalp hematoma was a major influence, 18 (78%) had a non-frontal hematoma and nine (39%) had scalp swelling that made the presence of skull fracture unclear. Mental status influenced decision making in 16 cases: nine (56%) had altered mental status (8 with a GCS of 14 and 1 somnolent) and 14 (88%) were acting abnormal per caregiver (11 somnolent and 3 irritable).

Among the 89 children who underwent observation and/or neuroimaging in the ED: 10 (11%) received antiemetic medication (i.e.

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