Emergency Department Practice Variation in Computed Tomography Use for Children with Minor Blunt Head Trauma

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Objective To describe factors associated with computed tomography (CT) use for children with minor blunt head trauma that are evaluated in emergency departments.

Study design Planned secondary analysis of a prospective observational study of children <18 years with minor blunt head trauma between 2004 and 2006 at 25 emergency departments. CT scans were obtained at the discretion of treating clinicians. We risk-adjusted patients for clinically important traumatic brain injuries and performed multivariable regression analyses. Outcome measures were rates of CT use by hospital and by clinician training type.

Results CT rates varied between 19.2% and 69.2% across hospitals. Risk adjustment had little effect on the differential rate of CT use. In low- and middle-risk patients, clinicians obtained CTs more frequently at suburban and nonfreestanding children's hospitals. Physicians with emergency medicine (EM) residency training obtained CTs at greater rates than physicians with pediatric residency or pediatric EM training. In multivariable analyses, compared with pediatric EM–trained physicians, the OR for CT use among EM-trained physicians in children <2 years was 1.24 (95% CI 1.04-1.46), and for children >2 years was 1.68 (95% CI 1.50-1.89). Physicians of all training backgrounds, however, overused CT scans in low-risk children.

Conclusions Substantial variation exists in the use of CT for children with minor blunt head trauma not explained by patient severity or rates of positive CT scans or clinically important traumatic brain injuries. *(J Pediatr 2014;165:1201-6)*.

Traumatic brain injury (TBI) is a major cause of death and disability in children, resulting in more than 7000 deaths, 60 000 hospitalizations, and more than 600 000 visits to the emergency department (ED) annually in the US.[1,2] Cranial computed tomography (CT) is the imaging modality of choice to identify TBI acutely, and many children (5%-70%)[3-5] seen in EDs with blunt head trauma are evaluated with CT scans. The use of CT, however, is variable between clinicians and hospitals[4,6] and appears unrelated to the frequency of clinically important TBIs (ciTBIs).[3,4,7-9] The reasons to use CT scanning judiciously include the risks of pharmacologic sedation,[10,11] the risk of radiation-induced malignancies, and cost.[12-17] Several studies have addressed variation in CT use after pediatric head trauma but are limited by their retrospective designs, performance in mostly children's hospitals, and lack of adjustment for risk of TBI.[3,4,6,8,18]

In 2009, two clinical prediction rules to identify children at very low risk of ciTBI after head trauma for whom CT scans typically are not indicated were derived and validated in the Pediatric Emergency Care Applied Research Network (PECARN).[7] Prospectively collected data from that study also enable the investigation of practice variation in CT use across a variety of providers and hospitals. Furthermore, the PECARN data enable stratification by risk of ciTBI, thus greatly mitigating methodological limitations of previous studies,[19] and provide evidence to empower clinicians (and families) with their clinical decision-making.

The purpose of this study was to evaluate variation in ED cranial CT use for children with minor blunt head trauma. We aimed to assess the degree of

ciTBI	Clinically important traumatic brain injury
CT	Computed tomography
ED	Emergency department
EM	Emergency Medicine
GCS	Glasgow Coma Scale
PECARN	Pediatric Emergency Care Applied Research Network
PEM	Pediatric Emergency Medicine
TBI	Traumatic brain injury

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Supported in part by the Health Resources and Services Administration (HRSA), Maternal and Child Health Bureau (MCHB; R40MC02461), the Emergency Medical Services of Children (EMSC) Program through the PECARN. PECARN is supported by the following cooperative agreements: U03MC00001, U03MC00003, U03MC00006, U03MC00007, U03MC00008, U03MC22684, and U03MC22685. The authors declare no conflicts of interest.

http://dx.doi.org/10.1016/j.jpeds.2014.08.008

variation, and identify hospital, physician, and patient factors associated with variation. Understanding variation in CT use should help to implement strategies to reduce unwarranted CT use.

Methods

This was a planned secondary analysis of data from a prospective observational multicenter study of children with minor blunt head trauma conducted in PECARN. Pertinent methods for this analysis are summarized herein; the full details of the parent study have been published previously.[7] This study was approved by the institutional review boards of all participating sites.

The parent study enrolled children from 25 EDs from June 2004 through September 2006. Eligible patients were seen within 24 hours of blunt head trauma and did not have neuroimaging obtained at outside hospitals before enrollment. We excluded patients with penetrating trauma, ventricular shunts, coagulopathies, brain tumors, or neurologic disorders that complicated clinical assessments. We defined patients with minor head trauma as those with Glasgow Coma Scale (GCS) scores of 14 or 15 on the initial ED evaluation.

ED physicians (faculty or fellows) completed standardized case report forms before obtaining CT results. Cranial CT scans were obtained at the discretion of the treating physicians after a complete history and physical examination. Hospital admission and subsequent management was also at the discretion of the treating physicians.

For hospitalized patients, site investigators reviewed medical records to obtain CT results and assess for ciTBIs. Standardized telephone interviews of guardians of patients discharged from the ED were completed 7-90 days after the ED visits, and, if the interview suggested a missed TBI, medical records and imaging results were reviewed to identify ciTBIs. If unable to contact the guardian, we reviewed medical records, trauma registries, and county morgue records to ensure no missed ciTBIs.

We defined a positive CT scan as any of the following: 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; or skull fracture depressed by at least the width of the skull table.

We defined ciTBI as death from TBI, neurosurgery, endotracheal intubation for more than 24 hours for TBI, or hospital admission of 2 nights or longer duration associated with a positive CT. This definition was intended to exclude brief intubations to complete imaging or overnight admissions for minor CT findings.

PECARN hospital characteristics were obtained from a separately published network survey.[20] We categorized sites as teaching or nonteaching (based on presence of residents in the ED >50% of the time), urban or suburban, and as freestanding or not-freestanding children's hospitals. We categorized emergency faculty and fellows by their residency training or certification as Emergency Medicine (EM) residency alone, Pediatric residency alone (Pediatrics), Pediatric EM (PEM), Internal Medicine, Family Medicine, or Other. For the analysis, we considered clinicians with dual training or certification in EM and Pediatrics as part of the PEM group, and we combined Internal Medicine and Family Medicine physicians into the "other" category. If a resident, nurse practitioner, or physician's assistant primarily evaluated the patient, we used the training or certification of the supervising physician.

Risk Stratification

We stratified each patient's risk of ciTBI by using the clinical factors in the 2 age-specific PECARN prediction rules (one for children <2 years of age and the second for those 2-18 years old) derived and validated in the parent study.[7] Using these risk factors, we categorized patients as low, middle, or high risk for ciTBI.[7] We classified patients with none of the PECARN risk factors in the age-specific prediction rules[7] as low risk. We considered patients with GCS scores of 14, other signs of altered mental status, palpable skull fractures (for children <2 years of age), or signs of basilar skull fracture (for children 2 years or older) to be high risk. We classified all other patients as middle risk.[7] Of note, the prediction rules were intended to identify low-risk patients for whom cranial CT scans can be obviated, not to identify patients for whom CT scans should be obtained. For purposes of the current study, however, we created high-, middle-, and low-risk strata to adjust for differences in severity case-mix of patients seen in different hospitals by different provider types.

Primary Outcome

The primary outcome measures for this study were as follows: (1) the rates of cranial CT scans obtained among the PECARN hospitals; and (2) the rates of obtaining CT scans by type of clinician training.

Statistical Analyses

We used descriptive statistics to summarize the data. We defined the CT rate as the number of CT scans divided by the number of patients evaluated. We defined the positive CT rate as the number of positive CT scans divided by the number of CT scans obtained and the rate of ciTBIs as the number of ciTBIs divided by the number of patients evaluated. For patients categorized as middle or high risk, we obtained a normalized rate of CT scans by dividing the number of CT scans obtained by the number of ciTBIs identified. In the low-risk stratum, there were very few ciTBIs, so this adjustment was not applicable. We sorted the hospitals based on their overall rate of CT scan use, with the same ordering of hospitals used in subsequent comparative analyses.

To compare CT use among clinician types, we performed two multivariable logistic regression analyses (one for patients <2 years of age and one for those ≥2 years of age). In these analyses, we adjusted for the PECARN rule risk strata