The Diagnosis of Concussion in a Pediatric Emergency Department

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Objectives To compare the proportion of children diagnosed with a concussion by pediatric emergency physicians vs the proportion who met criteria for this injury as recommended by Zurich Fourth International Conference on Concussion consensus statement and to determine clinical variables associated with a physician diagnosis of a concussion.

Study design This was a prospective, cross-sectional study conducted at a tertiary care pediatric emergency department. We enrolled children ages 5 through 17 who presented with a head injury and collected data on demographics, mechanism of injury, head injury-related symptoms/signs, physician diagnosis, and discharge advice.

Results We identified 495 children whose mean age was 10.1 years (SD 3.4 years); 308 (62.2%) were male. Emergency physicians diagnosed concussion in 200 (40.4%; 95% CI 36.1, 44.7) children, and 443 (89.5%; 95% CI 86.8, 92.2) met criteria for concussion in accordance with the Zurich consensus statement ($P < .0001$). Age ≥10 years (OR 1.8), presentation ≥1 day after injury (OR 2.4), injury from collision sports (OR 5.6), and symptoms of headache (OR 2.2) or amnesia (OR 3.4) were the variables significantly associated with an emergency physician's diagnosis of concussion.

Conclusions Pediatric emergency physicians diagnosed concussion less often relative to international consensus-based guidelines and used a limited number of variables to make this diagnosis compared with current recommendations. Thus, pediatric emergency physicians may be missing cases of concussion and the corresponding opportunity to provide critical advice for cognitive and physical management. *(J Pediatr 2015;166:1214-20)*.

Concussion is a common head injury, and there are approximately 250 000 pediatric concussion emergency department (ED) visits annually in the US.[1] Nevertheless, distinguishing a child's head injury as concussion vs a minor head injury without brain injury can be challenging for the ED physician. When obtained, standard neuroimaging is normal in both these types of head injuries.[2] Children <10 years of age report concussion symptoms differently than their older counterparts, and assessing subjective symptoms in young children can be difficult because of limited communication skills.[2-4] Finally, concussion signs and symptoms may develop within hours to days following an injury,[5] potentially underestimating the ED diagnosis of concussion in favor of a mild head injury.

Despite these challenges, an accurate and timely ED diagnosis of concussion in children is essential. The latter would enable clinicians to provide proper anticipatory guidance for optimal recovery from concussion,[6-8] minimizing risks of persistent postconcussive symptoms[9,10] and second impact syndrome, which may result in death.[11] In lieu of a reference standard based on objective physiological criteria or neuroimaging, the Zurich Fourth International Consensus Conference on Concussion statement developed a consensus statement for the diagnosis and management of concussion,[2] and these guidelines have been endorsed for children.[12] Surveys suggest that pediatric emergency physicians are applying these guidelines quite frequently in the ED to diagnosis and manage this brain injury.[13,14] However, in the absence of prospective clinical studies, use of these guidelines by pediatric emergency physicians remains relatively unknown.

In this study, we determined the frequency of pediatric emergency physician diagnosed concussion and compared it with the frequency of this injury identified by applying the diagnostic criteria in the Zurich Fourth International Conference consensus statements.[2,12] We hypothesized that these ED physicians would diagnose a lower frequency of concussion relative to that recommended by consensus guidelines.

Methods

This was a prospective, cross-sectional study conducted in an urban university-affiliated tertiary care pediatric ED. We enrolled a convenience sample of chil-

ChildSCAT3	Child Sport Concussion Assessment Tool 3
ED	Emergency department
SCAT3	Sport Concussion Assessment Tool 3

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Funded by the Hospital for Sick Children, via the Pediatric Research Academic Initiative at SickKids Emergency (PRAISE), and the Canadian Hospitals Injury Reporting and Prevention Program. The authors declare no conflicts of interest.

http://dx.doi.org/10.1016/j.jpeds.2015.02.013

dren ages 5-18 years who presented to the ED with a chief complaint of a direct head injury that occurred within 2 weeks of presentation to the ED. We excluded parents with an insurmountable English language barrier and children who presented as a major trauma. Further, children who presented outside study enrollment hours, had significant developmental delay, and/or had a final diagnosis unrelated to a head trauma were not enrolled. Children who were ultimately diagnosed with a structural head injury were excluded postenrollment. The Institutional Research Ethics Board approved the study.

Research assistants present in the ED from 8:30 a.m.-11 p.m. daily screened the electronic patient tracking system regularly to identify children presenting with a chief complaint of a head injury. Research assistants approached parents prior to the physician assessment to avoid survey bias. If eligible, the research assistant obtained full informed consent and assent when applicable. Research assistants completed a study data collection sheet with parents of enrolled children to capture demographic information (age, sex, number of days since injury, baseline frequency of contact sport participation, prior history of concussion), mechanism of current head injury, and new signs and symptoms reported since head injury. Sign and symptoms listed were extracted from those available on the Child Sport Concussion Assessment Tool 3 (ChildSCAT3)/ Sport Concussion Assessment Tool 3 (SCAT3), but parents were not provided the official SCAT3 checklists to avoid influencing parents and subsequent physicians about a diagnosis of concussion. Parents were asked to specify if the headache was localized to site of impact vs generalized, and they also were permitted to provide details on any other symptoms. Physicians performed their history and physical examination as per standard of care. A research assistant, trained in abstraction methods, documented type of head imaging performed and respective results, physician diagnosis, and discharge instructions (physician follow-up, anticipatory guidance regarding cognitive/physical rest, and specific use of return-to-play/ learn guidelines[15]). To identify missed cases, we retrospectively searched our ED electronic tracking system for complaints of "head injury, headache, altered level of consciousness, syncope, confusion and/or vision changes" and reviewed their ED record for potential eligibility. All study data were entered into Research Electronic Data Capture hosted at the study site.[16]

Consensus Statement Diagnostic Categories

A "structural head injury" referred to skull fractures and/or intracerebral hemorrhages/contusions. "Concussion" was defined by the Zurich Fourth International Conference consensus statement as a nonstructural, direct or indirect, head injury in which there is evidence of brain injury, identified as 1 or more symptoms/signs of brain dysfunction.[2,17] Brain dysfunction was defined as at least 1 sign or symptom on the ChildSCAT3/SCAT3 checklist that was new to the child since the head injury.[2,12,17] The latter definitions have been endorsed by an international team of experts who developed the guidelines for diagnosis and managing concussion for children 5-18 years and for any mechanism of injury.[12]

Pediatric ED Physician Practice Diagnostic Categories

A "concussion" was defined as those children with a nonstructural head injury and at least 1 of the final diagnoses on the ED record: concussion, mild traumatic brain injury, mild brain injury, or head injury with specific concussion discharge advice. A "mild head injury" included those children with a nonstructural head injury who had been given a final diagnosis of mild head injury by the ED physician, and there was a lack of any of the aforementioned diagnostic labels of concussion on the ED record. It is important to note that these ED physician diagnoses are the labels provided by the ED physician and not necessarily accurate or consistent with diagnostic criteria provided by the Zurich consensus statement. For example, children diagnosed with a "mild head injury" by ED physicians may meet diagnostic criteria for a concussion as per the Zurich consensus statement.

Activities

"Accidents" were classified as events that occurred during activities of daily living. "Recreational play" included activities that do not include an organized sport or sporting equipment. "Collision sports" were defined as those sports in which athletes purposely hit or collide with each other and included ice hockey, football, boxing, and lacrosse.

Outcomes

The primary outcome was the proportion of children diagnosed as a concussion by a staff pediatric emergency physician compared with the proportion of children who met diagnostic criteria for concussion as per Zurich Fourth International Consensus Statement on Concussion guidelines endorsed for children.[2,12] We also examined an ED physician's diagnosis of concussion and the association of this outcome with the following a priori selected variables [2,5,12,18-23]: demographic (male, age $\geq$ 10 years, child with a prior history of concussion, more than one day since head injury), injury from collision sport, and signs/symptoms that represent brain pathophysiology.[17] Finally, we reported the frequency of specific activity types that led to the head injury, and the proportion of children provided with return-to-play anticipatory guidance.

Statistical Analyses

Prior to this study, we conducted a retrospective review of children who presented to our ED with a nonstructural head injury over a 1-month period. We found that approximately 30% of children were diagnosed with a concussion by our emergency physicians, yet approximately 75% would have met criteria for this diagnosis as per Zurich Fourth International Consensus Statement on Concussion. Thus, given an estimated difference of 45%, a sample size of 500 would enable us to determine the true difference in sample populations with 95% certainty and a $\pm$4.5% margin of error (PASS 2011; v 11.0.7; NCSS, LLC, Kaysville, Utah).

Independent proportions were compared using a χ^2 test. McNemar test was used to assess differences in the proportion