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Predictors for moderate to severe paediatric head injury derived from a surveillance registry in the emergency department

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ABSTRACT

Introduction and aim: Head injuries are a common complaint among children presenting to the emergency department (ED). This study is part of an ongoing prospective surveillance of head injured children presenting to a paediatric ED. We aim to derive predictors for moderate to severe head injury in our population.

Materials and methods: We performed an unmatched case-control study. Cases were defined as those who presented to the ED with moderate to severe head injury, during the period from 2006 to 2014. Controls were obtained from the prospective surveillance head injury database and were children who presented to the ED with head injury but who remained well on follow up. We compared variables from demographics, mechanism of injury, history, and physical examination.

Results: There were 39 cases and 1173 controls. In the prospective database, our event rate was 0.5% and our computed tomography (CT) rate was 1%. Among those with moderate to severe head injury, they were more likely to be involved in road traffic accidents, have a history of difficult arousal, confusion or disorientation and a history of seizure. On physical examination, cases were more likely to have the presence of altered mental status, base of skull fracture, scalp hematoma and anisocoria. On multivariable analysis, the following 4 predictors remained statistically significant: Involvement in road traffic accident ($p < 0.001$), difficult arousal ($p < 0.001$), vomiting ($p = 0.003$) and signs of base of skull fracture ($p < 0.001$). Using these 4 variables, the Area under Curve was 0.97 {Sensitivity 92.3% (79.1–98.4%), Specificity 93.0% (91.4–94.4%), positive predictive value 30.5% (22–40%), negative predictive value 99.7% (99.2–99.9%)}.

Conclusion: Involvement in road traffic accident, difficult arousal, base of skull fracture and vomiting are independent predictors for moderate to severe head injury in our paediatric population.

Introduction

Head Injuries constitute a significant health burden [1]. In the paediatric emergency department (ED), the majority of the head injuries that present are mild, do not warrant further investigations, and have good clinical outcomes [2]. However, a small number do sustain significant traumatic brain injuries (TBI), and these children are at risk of mortality and long-term neurological disability. Early recognition and prompt management decreases mortality and morbidity [3].

In the ED, children with head injuries often present in a varied way. The ED physician often has difficulty in making prompt diagnostic and management decisions, due to the non-specific and age-dependent complaints and examination findings. While the fastest way to diagnose an intracranial injury is with the use of the computed tomography (CT) of the brain, the radiation to the young developing brain is significant and has been reported to be associated with ionizing malignancies [4,5]. The use of CT has increased with availability and the ease of acquiring the image [6][6]. Recently, large research networks have proposed head injury prediction rules to guide the ED physician in diagnosis and management of head injuries [7–9]. Others have encouraged the role of observation in majority of head injured cases, to allow for neuroimaging decisions to be made with more discretion [10]. The

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management of paediatric head injury remains varied between different centres and emergency departments [11]. Of note, an increase in short paediatric admissions has been noted [12]

In our centre, we are currently performing a prospective study that tracks all variables reported in the above clinical prediction rules, to assess the applicability of these to the local population. However, we noticed that the CT rate in our country is *much lower* than other centres (at less than 2%) compared to the CT rate of 30–50% reported in the above rules [8,9]. In our setting, we see a large number of young children presenting to the ED mostly after low mechanism falls, hence question the direct applicability of these rules in our context.

Our objective was to derive clinical predictors for moderate to severe head injury that would guide physicians facing a head injured child.

Methods

Study design, setting and participants

A case control design was chosen because of the low event rate. This study was performed in KK Women's and Children's Hospital, Singapore, with an annual census of about 178,000 patients. Cases were defined as patients less than 16 years old who presented to the ED with moderate to severe head injury (presenting Glasgow Coma Scale {GCS} of 13 or less), or those who presented with GCS 15 but subsequently deteriorated, and were confirmed on CT scan to have a bleed or fracture, during the period Jan 2006–June 2014. Controls were unmatched, and were obtained from the ongoing prospective head injury database starting in 2014. We excluded children presenting with falls who sustained only minor facial injuries. This database is electronically tracked and ensures complete documentation of every child who presents to the ED with head injury. It is mandatory for the ED physician to fill up each of the variables dictated for every child, and this data is subsequently electronically captured and followed up, on a daily basis.

After the ED attendance, the patients' health outcomes were followed. Patients discharged from the ED were given a follow up call 72 h later to ensure that the child had not deteriorated or attended at another centre with the need for neuroimaging. All admitted patients were followed up for in-hospital outcomes: length of hospital stay, need for mechanical ventilation, neurosurgery or death.

This study was given ethics approval by the local Institutional Review Board.

Variables

The variables were pooled from previously published prediction rules [7–9] and department protocols. Together with demographic data, we collected details surrounding the mechanism of injury and the presenting symptoms. The latter included the presence and duration of loss of consciousness, difficult arousal, vomiting, seizure activity or confusion. The ED physician determined during the consult if the child was preverbal or verbal. (This was not restricted based on age, due to child-to-child variability.) Presence of irritability was documented for preverbal children, while the presence of headache or amnesia was recorded for verbal children. For physical findings, apart from the GCS score, we also collected data on the presence of unequal pupils, signs of basal skull fracture, scalp hematoma, and focal neurological signs. Altered mental status was defined by the presence of: irritation, agitation, somnolence, repetitive questioning, slow response to verbal communication [8] or an unconscious patient. The location of the hematoma was documented. Signs of base of skull fracture included: bruising at the posterior auricular region, periorbital bruises, blood or cerebrospinal fluid from the nose or ears. Preverbal children with open fontanelles were examined for tense fontanelles. Ambulatory children were tested for gait.

Data sources

The details for the cases were obtained from retrospective chart review as well as from the prospective database. All controls were obtained from the prospective database.

Statistical methods

The demographics and clinical characteristics of the study population were described and compared among patients with (cases) and without TBI (controls), using Student *t*-tests for continuous variables and chi-square or Fisher exact test for categorical variables when appropriate.

To assess the probability of having TBI, we studied the predictive value of each of the variables in two steps. First we tested each of the collected variables in univariable logistic regressions (Odds ratios and their 95% confidence intervals presented as effect size). The variables a *p*-value below 0.2 were selected as well as factors presenting a clinical interest but which didn't reach statistical significance were also incorporated. Considering the age difference between the two groups, the models were adjusted for this confounder. Using a stepwise selection based on AIC, BIC and Log-Likelihood, we built the multivariable model yielding the best possible prediction. The ROC curve, along with measures of diagnostic accuracy which optimise the sensitivity and specificity, are presented for this final model.

Statistical significance was established as $p < 0.05$ and the data were analysed sing STATA v12 (Stata Corp, College Station, TX, USA).

Results

39 cases of moderate to severe head injured children and 1173 controls were obtained. The mean age of cases was 8 years while that of the controls was 5 years old ($p < 0.001$). Among the cases, there were 8 deaths and 26 patients who required neurosurgical intervention. Our event rate and CT rate on the prospective database was 0.5% and 1%, respectively.

Univariable analysis

Studying the variables more closely, the primary mechanism of injury was significant, with a significant number of cases involved in a road traffic accident (44%) as compared to controls (2%) ($p < 0.001$). The majority of the controls sustained their head injury from falls (Table 1). Among all children with falls, the median height of the fall was not statistically significant ($p = 0.069$). In fact, 7 out of 19 falls (36.8%) were ground level falls. Specifically looking at preverbal children aged 2 years and under, a similar trend was seen, with road traffic accident being significant for traumatic brain injury in this age group as well ($p = 0.012$). There were only 2 cases attributed to non-accidental injury.

Further details from history and physical examination are described in Table 2.

Among those with a history of loss of consciousness (LOC), those with a LOC period of more than 1 min were more likely to have sustained a traumatic brain injury. Difficult arousal, confusion or disorientation were statistically significant through all ages. The presence of irritability among preverbal children, and headache or amnesia among verbal children, were non-discriminatory. Altered mental status, signs of base of skull fracture, unequal pupils, scalp hematoma and the presence of tense