

Factors associated with unfavorable outcomes following mild pediatric head injuries in a reference center of the north region of Minas Gerais

Fatores associados a desfechos desfavoráveis após trauma craniano leve pediátrico em um centro de referência da região norte de Minas Gerais

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ABSTRACT

Study Design: Prospective cohort. **Objective:** To describe clinical and demographic characteristics of a sample of children with HI referred for acute care in a referral center of the north region of Minas Gerais, Brazil, and assess clinical and radiological markers associated with unfavorable outcomes. **Methodology:** All children between the ages 0 to 14 years referred with head injury from February to September 2011 were included in this study. Socio-demographic and clinical data were collected at the moment of the initial assessment under informed consent. The patients were also reassessed via telephone calls after 7 and 91 days. **Results:** A total of 77 patients were included in this study. The mean age was 3.9 years with a standard deviation of 3.76 years. Falls and bicycle collisions were the main mechanisms of trauma. The most relevant clinical marker associated with unfavorable outcomes at 7 days was the parental perception of unusual behavior (Odds Ratio = 11.33; 95% confidence interval: 1.38-93.13; $p = 0.02$). Computer tomography scan abnormalities were associated with both unfavorable outcomes at 7 days ($p=0.03$) and at 91 days ($p=0.02$). **Conclusions:** The peculiar aspects of head injuries in a Brazilian population were described in this study. It was also found that unusual behavior and abnormalities on CT scan are factors that predict unfavorable outcomes in children with mild HI in this population.

Keywords: Brain Injuries. Child. Craniocerebral Trauma.

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Artigo recebido em 18/01/2013
Aprovado para publicação em 05/05/2014

Introduction

Head injury (HI) is a major cause of mortality and disability in the pediatric population throughout the world.¹ Children disability secondary to HI is also associated with significant caregiver burden.²

As poor outcomes are more common in patients with moderate or severe head injuries, hospital-based studies have focused in the outcomes of these patients.³ However, recent studies have raised concerns about the long-term consequences of the mild traumatic brain injury (TBI).⁴ Furthermore, as mild HI is much more common, it is expected that mild TBI has a greater contribution to the overall burden of disability.⁴

The objective of this study was to describe clinical and demographic characteristics of a sample of children with HI referred for acute care in a referral center of the north region of Minas Gerais, Brazil. Clinical and radiological markers associated with unfavorable outcomes were assessed.

Material and methods

This study was conducted in the main referral hospital for emergency neurological care in the north region of Minas Gerais, Brazil, in a city called Montes Claros. That hospital covers a local population of over 400,000 inhabitants and receives referrals from a territory with over 1,600,000 inhabitants.

Following approval of the local ethics committee, all children between the ages 0 to 14 years referred with head injury from February to September 2011 were included in this study. Socio-demographic and clinical data were collected at the moment of the initial assessment under informed consent. Glasgow Coma Scale (GCS) was used to classify the HI into three levels of severity.⁵ Conscience in children below 4 years-old was evaluated with the pediatric scale described by James and Trauner.⁶ Trauma mechanisms were categorized as mild, moderate or severe as previously described.⁷ The patients were also reassessed via phone calls after 7 and 91 days (13 weeks) for the presence of unfavorable outcomes.

In this study an unfavorable outcome was defined as the presence of any of the following: persistence of symptoms (headache, vomiting and dizziness), neurological impairments (cognitive, sensitive or motor deficits, behavior changes, sleep disturbances and seizure), weight changes, hospital admission and death.

All data analysis was performed in the free software R version 3.0.0 for Windows.⁸ The effects of the clinical variables on the presence of unfavorable outcomes at 7 and 91 days were calculated using the multiple logistic regression model. The association of these outcomes and abnormalities in computer tomography scan was evaluated with the Pearson's Chi squared test. The characteristics of the patients who lost the follow-up were compared to those that completed it using Pearson's Chi squared test. Missing data were excluded from the analysis. Results were considered significant under the level of 5% ($p < 0.05$).

Results

Demographic features

A total of 77 patients were included in this study. The majority of the patients were from the city in which the hospital is located ($n=72$; 93.5%) and the remaining ($n=5$; 6.5%) were from cities up to 188 km away. There was a slight predominance of males ($n=44$; 57.1%). The mean age was 3.9 years with a standard deviation of 3.76 years.

Timing and injury variables

Children generally arrived in hospital by car ($n=40$; 51.9%), accompanied by their parents ($n=74$; 96.1%), after 5.98 hours in average after the trauma. The main trauma mechanisms were falls from height ($n = 27$; 37.0%) or falls while standing, walking or running ($n=14$; 18.2%). Bicycle collisions were the third most common mechanism ($n=11$; 14.29%). Importantly, in none of the cases, the children were wearing helmets (see table 1).

The trauma generally occurred at the child's home ($n = 41$; 53.3%) or in the street ($n=16$; 20.76%), while under supervision of their parents ($n = 36$; 46.7%).

Clinical manifestations

The main symptoms reported were headache ($n=42$; 54.6%; participants with missing data = 7) and unusual behavior ($n=21$; 27.3%; participants with missing data = 1). Only five children had a history of loss of conscience, although it was dubious in six others. Conscience was normal (GCS = 15) in most cases at the moment of the evaluation. Only three cases had a GCS of 14 and one case presented with a GCS of 3.

Table 1: Trauma mechanisms in the sample

Trauma mechanism	n	%
Falls from height	27	37.0%
Falls while standing, walking or running	14	18.2%
Bicycle collisions	11	14.3%
Falls from stairs	7	9.1%
Motor vehicle-related	7	7.8%
Sports-related	2	2.6%
Others	9	11.7%

Physical findings were generally normal, with the exception of scalp hematomas that were present in 26 cases (33.8%; missing = 1). Anisocoric pupils were present in two cases; nonreactive pupils, orbital ecchymosis, cerebrospinal fluid otorrhea and rhinorrhea were present in only one case.

Only 2 patients had epilepsy or other neurological diseases and 13 patients (16.88%) had been evaluated before for HI in the emergency department.

Management

The majority of patients were only observed in the emergency department and treated for their symptoms. Instructions to the parents regarding alarming signs were also provided. Only one patient was treated with surgery (decompressive craniectomy and hematoma drainage).

Outcomes

Out of the 77 patients, only one died from head injury. Of those 76 surviving (all of which had a GCS of 14 or 15), follow-up phone interviews were obtained from 62 children (81.58%) at 7 days after the injury and from 47 children (61.84%) at 91 days. The group of patients who completed the follow-up did not differ from those that lost it, regarding demographic, clinical and radiological characteristics at the initial evaluation ($p > 0.05$), with the exception of the proportion of patients with less than 4 years, which was higher in the latter group ($p = 0.049$).

At 7 days, 13 children (20.97%) had some type of unfavorable outcome, including persistent headache ($n=4$), vomiting ($n=4$), hospital admission ($n=2$), behavior change ($n=1$), dizziness ($n=1$) and sleep abnormality ($n=1$). The most relevant clinical marker

associated with unfavorable outcomes at 7 days, was the parental perception of unusual behavior (Odds Ratio (OR) = 11.33; 95% confidence interval (95% CI): 1.38-93.13; $p = 0.02$). A history of a non-mild trauma mechanism and the presence of scalp hematoma also presented a trend toward significance (see table 2). At 91 days, unfavorable outcomes were reported for 4 children (8.51%), including weight changes ($n=3$) and increased frequency of headaches ($n=1$). Additionally, 18 children interviewed at 91 days (52.94%) missed school classes for up to three weeks. None of the clinical markers were associated with unfavorable outcomes at 91 days, although the parental perception of unusual behavior and an age below 4 years presented a trend toward significance ($p < 0.10$; data not shown).

Computer tomography scan (CT scan) was performed to 21 patients (27.6%). The most important clinical factors that were associated a CT scan request were a history of loss of conscience and of abnormal behavior (see table 3). Abnormalities on CT scan were associated with unfavorable outcomes at both 7 days ($p=0.03$) and 91 days ($p=0.02$). CT scan request was not associated, in itself, with the informed unfavorable outcomes (data not shown).

Discussion

This study reported for the first time the characteristics of pediatric head injuries in the north of Minas Gerais, Brazil. The predominance of boys in our study follows a universal finding.^{9,10,11} When analyzing the causes of head injury in that population, we observe the predominance of falls, either from heights, stairs or while standing, walking or running (table 1).

Table 2: Clinical markers and their associations with unfavorable outcomes after 7 days

Clinical marker	OR (95% CI)	p
Male gender	3.99 (0.43-36.61)	0.22
Age less than 4 years	1.52 (0.22-10.34)	0.66
Non-mild mechanism	6.71 (0.64-53.36)	0.09
History of loss of conscience	1.29 (0.07-25.59)	0.87
Abnormal behavior	11.33 (1.38-93.13)	0.02*
Headache	0.16 (0.01-4.83)	0.29
Previous head injury	0.29 (0.02-3.77)	0.34
Scalp hematoma	6.05 (0.69-53.25)	0.10
Vomiting	0.64 (0.10-4.08)	0.63

OR = Odds Ratio; CI = Confidence Interval.

Table 3: Clinical markers and their associations with Computer Tomography scan request

Clinical marker	OR (95% CI)	p
Male gender	0.78 (0.20-3.06)	0.72
Age less than 4 years	0.48 (0.10-2.24)	0.35
Non-mild mechanism	3.14 (0.62-15.58)	0.17
History of loss of conscience	10.67 (1.33-85.64)	0.03*
Abnormal behavior	5.52 (1.19-25.40)	0.03*
Headache	0.10 (0.01-1.67)	0.11
Previous head injury	0.78 (0.12-5.00)	0.80
Scalp hematoma	1.60 (0.38-6.63)	0.52
Vomiting	3.12 (0.80-12.28)	0.10

OR = Odds Ratio; CI = Confidence Interval. * p < 0.05.

While some authors also found an important role of falls,⁹ others have identified greater contributions of motor vehicle crashes^{1,10} and sports-related injuries.¹¹ This discrepancy can be explained by distinct mean ages of the children and by cultural differences.

Injuries of the brain in children have important distinctions from those occurring in adulthood. In the immature brain, functional specificity is not complete and this fact has been associated with a better recovery from injuries, via modification of neural circuitry, a phenomenon called plasticity. However, an injury

to a developing brain can also disrupt a predetermined developmental process, resulting in a somewhat contradictory higher vulnerability.¹²

In this sense, although HI is generally mild and rarely fatal, the occurrence of impairments in children after mild HI is well described, especially for the neuropsychological domains.^{13,14,15} These impairments can be subtle and become more evident in the long term. This delayed effect can be partly explained by the neuroinflammation process that can persist for even months.¹⁶

In our sample, persistent headache, vomiting, behavior change, dizziness and sleep abnormality were reported at 7 days following the injury. These abnormalities were mostly transient and were not present when they were reassessed at 91 days, with the exception of headache. Accordingly, it was previously described a higher incidence of headache after 3 months in children suffering a mild HI, when compared to children with arm injury.¹⁷

Weight gain is another established complication of HI and can result in a mean body mass index (MBI) z-score increase of 0.4.¹⁸ Obesity after traumas is often referred as a type of “hypothalamic obesity”.¹⁹ On the other hand, weight loss was also reported as a complication of head injuries.²⁰ From all the patients evaluated after 91 days in this study, one had gained weight, while in two other cases a weight loss was reported.

CT scan, when indicated, can be very useful to guide the therapeutic decisions in the emergency setting. In this study, although CT scans did not modify the treatment in any of the children with a GCS of 14 or 15, abnormal findings were associated to unfavorable outcomes in the two evaluated moments, suggesting that it can aid in the prediction of these outcomes.

It is important to emphasize, however, that routine radiological examinations can represent a finan-

cial burden, especially in low-income countries, and that they are associated with considerable radiation exposure and increased risk of malignancy.²¹ Considering this, we also seek the identification of clinical markers of unfavorable outcomes. The factor most strongly associated with these outcomes was the parental report of abnormal behavior (table 2). This factor also influenced the physician request of CT scans (table 3). Accordingly, parental report of whether the patient is acting normally has been included in decision trees for CT scan recommendation.⁷

This study has some limitations. Our sample can be considered small and markers with lower, but still relevant associations with poor outcomes might be missed. Another limitation is that the patients were not seen in the follow-up interviews, but were assessed by telephone only. Although telephone interviews were previously used in the follow-up of children with HI,⁷ additional studies with a higher number of participants and with physical examinations on follow-up are important to confirm these results and extend them to other populations.

In summary, the peculiar aspects of the head injuries in the pediatric population of the North of Minas Gerais were described. It was also found that unusual behavior and abnormalities on CT scan are factors that predict unfavorable outcomes in children with mild HI in this population.

RESUMO

Modelo do Estudo: Coorte prospectivo. **Objetivo do Estudo:** Descrever características clínicas e demográficas de uma amostra de crianças encaminhadas por traumatismo craniano em um centro de referência na região norte de Minas Gerais e avaliar marcadores clínicos e radiológicos associados a desfechos desfavoráveis. **Metodologia:** Foram incluídas neste estudo todas as crianças entre 0 e 14 anos atendidas com traumatismo craniano de fevereiro a setembro de 2011. Dados sócio demográficos e clínicos foram coletados no momento da avaliação inicial sob consentimento informado. Os pacientes também foram reavaliados por telefone após 7 e 91 dias. **Resultados:** Um total de 77 pacientes foi incluído neste estudo. A idade média foi de 3,9 anos, com desvio padrão de 3,76 anos. Quedas e colisões de bicicleta foram os principais mecanismos de trauma. O marcador clínico mais relevante associado a desfechos desfavoráveis com 7 dias foi a percepção pelos pais de comportamento anormal (Odds Ratio = 11,3; intervalo de confiança de 95%: 1,38-93,13; p = 0,02). Alterações na Tomografia Computadorizada foram associadas tanto a desfechos desfavoráveis após 7 dias (p=0,03) como após 91 dias (p=0,02). **Conclusões:** Os aspectos peculiares do traumatismo craniano em uma população brasileira são descritos neste estudo. Encontrou-se, ainda, que um comportamento anormal e alterações na TC são fatores que predizem desfechos desfavoráveis em crianças com traumatismo craniano leve nessa população.

Palavras-Chave: Traumatismos encefálicos. Criança. Traumatismos craniocerebrais.

References

1. Kraus JF, Rock A, Hemyari P. Brain injuries among infants, children, adolescents, and young adults. *Am J Dis Child.* (1960) 1990; 144: 684-91.
2. Aitken ME, McCarthy ML, Slomine BS, Ding R, Durbin DR, Jaffe KM, et al. Family Burden After Traumatic Brain Injury in Children. *Pediatrics.* 2009; 123: 199-206.
3. Yeates KO, Taylor HG, Wade SL, Drotar D, Stancin T, Minich N. A prospective study of short- and long-term neuropsychological outcomes after traumatic brain injury in children. *Neuropsychology.* 2002; 16: 514-23.
4. Rivara FP, Koepsell TD, Wang J, Temkin N, Dorsch A, Vavilala MS, et al. Incidence of disability among children 12 months after traumatic brain injury. *Am J Public Health.* 2012; 102: 2074-9.
5. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. *Lancet.* 1974; 2 (7872): 81-4.
6. James HE, Trauner DA. The Glasgow Coma Scale. In: James HE, Anas NG, Perkin RM, editors. *Brain insults in infants and children: pathophysiology and management.* Orlando: Grune & Stratton; 1985.
7. Kuppermann N, Holmes JF, Dayan PS, Hoyle JD, Atabaki SM, Holubkov R, et al. Identification of children at very low risk of clinically-important brain injuries after head trauma: a prospective cohort study. *Lancet.* 2009; 374: 1160-70.
8. R Core Team. *R: A Language and Environment for Statistical Computing.* Vienna, Austria: R Foundation for Statistical Computing; 2013.
9. Koepsell TD, Rivara FP, Vavilala MS, Wang J, Temkin N, Jaffe KM, et al. Incidence and descriptive epidemiologic features of traumatic brain injury in King County, Washington. *Pediatrics.* 2011; 128: 946-54.
10. Alhabdan S, Zamakhshary M, AlNaimi M, Mandora H, Alhamdan M, Al-Bedah K, et al. Epidemiology of traumatic head injury in children and adolescents in a major trauma center in Saudi Arabia: implications for injury prevention. *Ann Saudi Med.* 2013; 33: 52-6.
11. Crowe L, Babl F, Anderson V, Catroppa C. The epidemiology of paediatric head injuries: Data from a referral centre in Victoria, Australia. *J Paediatr Child Health.* 2009; 45: 346-50.
12. Anderson V, Spencer-Smith M, Wood A. Do children really recover better? Neurobehavioural plasticity after early brain insult. *Brain.* 2011; 134: 2197-221.
13. Ewing-Cobbs L, Barnes M. Linguistic outcomes following traumatic brain injury in children. *Semin Pediatr Neurol.* 2002; 9: 209-17.
14. Fay GC, Jaffe KM, Polissar NL, Liao S, Rivara JB, Martin KM. Outcome of pediatric traumatic brain injury at three years: a cohort study. *Arch Phys Med Rehabil.* 1994; 75: 733-41.
15. Yeates KO, Swift E, Taylor HG, Wade SL, Drotar D, Stancin T, et al. Short- and long-term social outcomes following pediatric traumatic brain injury. *J Int Neuropsychol Soc.* 2004; 10: 412-26.
16. Whitney NP, Eidem TM, Peng H, Huang Y, Zheng JC. Inflammation mediates varying effects in neurogenesis: relevance to the pathogenesis of brain injury and neurodegenerative disorders. *J Neurochem.* 2009; 108: 1343-59.
17. Blume HK, Vavilala MS, Jaffe KM, Koepsell TD, Wang J, Temkin N, et al. Headache after pediatric traumatic brain injury: a cohort study. *Pediatrics.* 2012; 129: e31-9.
18. Jourdan C, Brugel D, Hubeaux K, Toure H, Laurent-Vannier A, Chevignard M. Weight gain after childhood traumatic brain injury: a matter of concern. *Dev Med Child Neurol.* 2012; 54: 624-8.
19. Toledo E, Lebel A, Becerra L, Minster A, Linnman C, Maleki N, et al. The young brain and concussion: imaging as a biomarker for diagnosis and prognosis. *Neurosci Biobehav Rev.* 2012; 36: 1510-31.
20. Morris PG, Prior L, Deb S, Lewis G, Mayle W, Burrow CE, et al. Patients' views on outcome following head injury: a qualitative study. *BMC Fam Pract* 2005; 6: 30.
21. Printz C. Computed tomography scans and cancer risk: The latest findings. *Cancer.* 2013; 119: 701-2.