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# HYPERGLYCEMIA IN PEDIATRIC HEAD TRAUMA PATIENTS

## A cross-sectional study

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**Abstract** – **Objective:** To verify the prevalence of acute hyperglycemia in children with head trauma stratified by the Glasgow coma scale (GCS). **Method:** A prospective cross-sectional study carried out with information from medical records of pediatric patients presenting with head injury in the emergency room of a referral emergency hospital during a one year period. We considered the cut-off value of 150 mg/dL to define hyperglycemia. **Results:** A total of 340 children were included and 60 (17.6%) had admission hyperglycemia. Hyperglycemia was present in 9% of mild head trauma cases; 30.4% of those with moderate head trauma and 49% of severe head trauma. We observed that among children with higher blood glucose levels, 85% had abnormal findings on cranial computed tomography scans. **Conclusion:** Hyperglycemia was more prevalent in patients with severe head trauma (GCS ≤8), regardless if they had or not multiple traumas and in children with abnormal findings on head computed tomography scans.

KEY WORDS: adolescents, children, head trauma, hyperglycemia, prevalence.

**Hiperglicemia em pacientes pediátricos com traumatismo craniencefálico: estudo de corte transversal**

**Resumo** – **Objetivo:** Verificar a prevalência de hiperglicemia aguda em crianças vítimas de trauma craniencefálico, de acordo com a escala de coma de Glasgow (GCS). **Método:** Estudo prospectivo, de corte transversal realizado por meio do acompanhamento de prontuários médicos de pacientes na faixa etária pediátrica admitidos na unidade de urgência de um hospital de referência vítimas de traumatismo craniencefálico, durante um ano. Consideramos o valor de corte em 150 mg/dL para definição de hiperglicemia. **Resultados:** 340 crianças foram incluídas no estudo e 60 (17,6%) apresentaram hiperglicemia na admissão. Hiperglicemia esteve presente em 9% dos casos de trauma craniano leve, 30,4% daqueles com trauma craniano moderado e em 49% dos pacientes com trauma craniano grave. Verificamos que, entre as crianças com níveis elevados de glicemia, 85% apresentavam alterações radiológicas verificadas na tomografia computadorizada do crânio. **Conclusão:** A hiperglicemia foi mais prevalente em pacientes com traumatismo craniano grave (GCS ≤8), assim como naqueles com alterações identificadas na tomografia computadorizada do crânio, independente da presença de politraumatismo.

PALAVRAS-CHAVE: adolescentes, crianças, trauma craniocerebral, hiperglicemia, prevalência.

Guidelines for diabetes diagnosis and classification are widely described[1,2]. However, high blood glucose is common in acutely ill neurological patients, even in non-diabetics ones. A consensus regarding the cut-off blood glucose level that would be related to a poor prognosis in children and adolescents with head trauma is still lacking, which makes the comparison of different studies particularly troublesome[3-9].

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Some authors believe that patients with hyperglycemia generally have a low Glasgow Coma Scale (GCS) score[3-6], poor neurological prognosis (based on GCS) and a history of severe trauma with significant brain injury[6,7]. It is well known that such acute hyperglycemia is a result of catecholamine' effects[8,9]. Some authors, however, disagree on the association of hyperglycemia and poor prognosis, particularly in children and adolescents, as high blood glucose levels are transient and basically reflect a body response after injury[10].

In the present study we aimed to verify the prevalence of acute hyperglycemia in pediatric patients with head trauma, according to the severity of head injury.

## METHOD

### Study design and data collection

A prospective cross-sectional study was carried out with information derived from medical records of pediatric patients with head trauma. Data collected from medical records included age, sex, mechanism of injury, classification of trauma (isolated head trauma or multiple trauma), GCS score and blood glucose level on admission and cranial computed tomography (CCT) scan results.

Medical records of patients aged from 0 to 18 years-old with head trauma presented in the emergency room of a referral Emergency Hospital in Salvador, Bahia, Brazil, from May 2007 to July 2008 were evaluated. World Health Organization (WHO) definition for pediatric age was used here[11]. Severity of head trauma was accessed by GCS score on admission, and when necessary the modification for use in children under 2 years[12-14]. Findings on the CCT scan considered to be abnormal included any brain lesion such as brain swelling, diffuse axonal injury and intracranial hemorrhages. The CCT scans were done in the same hospital and at the same model of tomography machine. The results were checked by experienced radiologists and neurosurgeons.

Exclusion criteria included a previous diagnosis of diabetes, absence of GCS score, CCT scan or blood glucose levels on the first 24h of admission and hospital stay less than 48h.

### Hyperglycemia

Blood glucose levels were determined by capillary blood glucose obtained through fingertips' puncture at hospital admission. The results were shown in digital blood glucose monitor. This same technique was used in every patient. We considered values above 150mg/dl as hyperglycemia, like other authors have already claimed[3].

### Ethical concerns and data analyses

The study was approved by the Hospital Ethics Committee under registration n° 06/07. Either parents or other legally responsibles signed informed consent before inclusion in the study. No extra exams, besides the ones usually performed in an Emergency Room, were done.

Categorical data were analyzed by using $\chi^2$ analyses and Pearson analysis was used to verify correlation between GCS and blood glucose level on admission.

## RESULTS

A total of 340 patients were eligible for inclusion. Mean age was 9.8 (±6) years; 73.2% were male. Regarding the type of trauma, the most frequent were fall from a height (34.1%) and vehicle-pedestrian accidents (18.2%). Regarding the GCS classification, 245 (72.1%) patients had mild head trauma (GCS 13–15), 46 (13.5%) had moderate head trauma (GCS 9–12), whereas 49 (14.4%) suffered severe head trauma (GCS 3–8).

Concerning blood glucose levels on admission, 60 (17.6%) patients had hyperglycemia. Hyperglycemia was found in 73.3% of male patients and 55% of traffic accidents victims. The prevalence of hyperglycemia increased proportionally to the head trauma severity: 9% in mild head trauma, 30.4% in moderate head trauma ($p<0.01$ when compared to mild head trauma) and 49% in cases considered severe ($p<0.01$ when compared to mild head trauma). An inverse relationship between admission glucose levels and GCS score was found, using Pearson analysis ($r=0.32$; $p=0.01$).

Regarding the cases of isolated head trauma or multiple traumas, in those with isolated head injury we observed hyperglycemia in 15% versus 20% of the other group ($p=0.28$). Brain swelling (32%), and intracranial hemorrhages (20%) were the most important abnormal findings on CCT scan. Among hyperglycemic patients, 85% had abnormal brain parenchymal findings. However only 35.6% of the normoglycemic patients had abnormal brain parenchymal findings according CCT scans results.

## DISCUSSION

In accordance with previous studies[15], our findings showed the predominance of male sex and falls in pediatric head trauma victims. We did not observe statistical differences in hyperglycemia prevalence regarding sex ($p=0.98$) and type of trauma. Regarding the GCS classification, we find a preponderance of mild head trauma victims, which is also widely described in previous studies. It is important to notice that patients with mild head trauma generally stay in hospital for short periods of time, have less severe or no brain damage and do not suffer a meaningful metabolic response related to trauma[16], so it is not usual to diagnose hyperglycemia in those patients.

Hyperglycemia is indeed more frequently observed in severe head trauma victims and in those that suffered multiple trauma, according to some studies[3,4,6,17,18]. The explanation would be that these patients have a more important metabolic response to injury due to the effects of cortisol, glucagon and epinephrine release, causing intrac-

ellular acidosis, lactate accumulation, high blood glucose levels and neuronal injury[6,19-21]. Therefore, our data are in accordance with the results from other authors who correlate the head trauma severity and the metabolic response to trauma, particularly higher blood glucose levels[7,22,23]. Some studies show that hyperglycemia is associated with a worse outcome, regardless of injury characteristics[24].

We did not observe statistically significant differences in blood glucose levels in patients with isolated head injury and in the ones with multiple traumas. The probable cause might be that we considered multiple trauma any kind of injury associated with head trauma, regardless of the degree of injury. We could have overestimated the amount of multiple trauma victims.

The observation of abnormal CCT findings was more frequent in hyperglycemic patients. Such an association was also described by previous studies and possible explanations would be that brain injury evokes a metabolic response that results in hyperglycemia and/or that hyperglycemia itself is responsible for more meaningful brain lesions on CCT scans[25,26]. Our knowledge up to now does not permit to conclude if a high blood glucose level is a mediator or a marker of brain injury.

Inclusion the prevalence of hyperglycemia is higher in patients with severe head trauma, as well as in those with abnormal findings on CCT scans. All these variables are generally associated with significant brain tissue lesion. We cannot conclude if the higher blood glucose levels are responsible for poorer outcomes in the present observation. The meaning of hyperglycemia in the outcomes of children and adolescents with severe head trauma will be analyzed in a future study.

## REFERENCES

1. Kuzuya T, Nakagawa S, Satoh J, et al. Report of the Committee on the classification and diagnostic criteria of diabetes mellitus. Diabetes Res Clin Pract 2002;55:65-85.
2. Tominaga M. [Diagnostic criteria for diabetes mellitus]. Rinsho Byori 1999;47:901-908.
3. Chiaretti A, De BR, Langer A, et al. Prognostic implications of hyperglycaemia in paediatric head injury. Childs Nerv Syst 1998;14:455-459.
4. Chiaretti A, Piastra M, Pulitano S, et al. Prognostic factors and outcome of children with severe head injury: an 8-year experience. Childs Nerv Syst 2002;18:129-136.
5. Cochran A, Scaife ER, Hansen KW, Downey EC. Hyperglycemia and outcomes from pediatric traumatic brain injury. J Trauma 2003;55: 1035-1038.
6. Lam AM, Winn HR, Cullen BF, Sundling N. Hyperglycemia and neurological outcome in patients with head injury. J Neurosurg 1991;75: 545-551.
7. Sung J, Bochicchio GV, Joshi M, Bochicchio K, Tracy K, Scalea TM. Admission hyperglycemia is predictive of outcome in critically ill trauma patients. J Trauma 2005;59:80-83.
8. Schelp AO, Burini RC. [Cerebral glucose metabolism in craniocerebral trauma: an evaluation]. Arq Neuropsiquiatr 1995;53:698-705.
9. Yamaguchi N. Sympathoadrenal system in neuroendocrine control of glucose: mechanisms involved in the liver, pancreas, and adrenal gland under hemorrhagic and hypoglycemic stress. Can J Physiol Pharmacol 1992;70:167-206.
10. Parish RA, Webb KS. Hyperglycemia is not a poor prognostic sign in head-injured children. J Trauma 1988;28:517-519.
11. World Health Organization. Child and adolescent health and development. Available at (http://www.who.int/en/) Accessed November 01, 2007.
12. Teasdale G, Jennett B. Assessment of coma and impaired consciousness. A practical scale. Lancet 1974 13;7872;81-84.
13. Marcoux KK. Management of increased intracranial pressure in the critically ill child with an acute neurological injury. AACN Clin Issues 2005;16:212-231.
14. Orliaguet GA, Meyer PG, Baugnon T. Management of critically ill children with traumatic brain injury. Paediatr Anaesth 2008;18 :455-461.
15. Melo JR, Santana DL, Pereira JL, Ribeiro TF. [Traumatic brain injury in children and adolescents at Salvador City, Bahia, Brazil]. Arq Neuropsiquiatr 2006;64:994-996.
16. Melo JR, Silva RA, Moreira ED Jr. [Characteristics of patients with head injury at Salvador City (Bahia--Brazil)]. Arq Neuropsiquiatr 2004;62;711-714.
17. Bochicchio GV, Sung J, Joshi M, et al. Persistent hyperglycemia is predictive of outcome in critically ill trauma patients. J Trauma 2005;58;921-924.
18. Bochicchio GV, Joshi M, Bochicchio KM, et al. Early hyperglycemic control is important in critically injured trauma patients. J Trauma 2007;63;1353-1358.
19. Epstein J, Breslow MJ. The stress response of critical illness. Crit Care Clin 1999;15;17-33.
20. Hirsch IB. In-patient hyperglycemia--are we ready to treat it yet? J Clin Endocrinol Metab 2002;87;975-977.
21. Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE. Hyperglycemia: an independent marker of in-hospital mortality in patients with undiagnosed diabetes. J Clin Endocrinol Metab 2002;87;978-982.
22. Parejo P, Stahl N, Xu W, Reinstrup P, Ungerstedt U, Nordstrom CH. Cerebral energy metabolism during transient hyperglycemia in patients with severe brain trauma. Intensive Care Med 2003;29;544-550.
23. Jeremitsky E, Omert LA, Dunham CM, Wilberger J, Rodriguez A. The impact of hyperglycemia on patients with severe brain injury. J Trauma 2005;58;47-50.
24. Laird AM, Miller PR, Kilgo PD, Meredith JW, Chang MC. Relationship of early hyperglycemia to mortality in trauma patients. J Trauma 2004;56;1058-1062.
25. Durr JA, Hoffman WH, Sklar AH, el GT, Steinhart CM. Correlates of brain edema in uncontrolled IDDM. Diabetes 1992;41;627-632.
26. Kushner M, Nencini P, Reivich M, et al. Relation of hyperglycemia early in ischemic brain infarction to cerebral anatomy, metabolism, and clinical outcome. Ann Neurol 1990;28: 129-135.