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ORIGINAL ARTICLE

Epidemiology of traumatic head injury among children presenting to a tertiary hospital in Riyadh

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ABSTRACT

Background: Traumatic brain injury (TBI) is a leading cause of mortality and morbidity in children. The aim of this study was to report the burden of isolated pediatric TBI at a major trauma center in Riyadh, Saudi Arabia and assess associations with mechanism of injury.

Methods: A retrospective cohort study using chart review, including children aged ≤14 years with isolated TBI over 2 years from 01 Jan 2016 to 31 Dec 2017 was undertaken. Univariable or unadjusted associations of patients presenting after motor vehicle crashes (MVC) and physiological variables were assessed. Intensive care unit (ICU) admission and mortality at hospital discharge were the primary outcome measures.

Results: There were 2,501 pediatric patients that presented to the Emergency Department with head injury and 241 (9.6%) patients were admitted to hospital with isolated TBI, with an in-hospital mortality rate of 9%. MVC was the most common mechanism of injury (n = 142; 59%) followed by falls (n = 68; 28.2%), pedestrians (n = 26; 10.8%), and non-accidental injuries (n = 5; 2.1%). Patients presenting after MVC were older (p = 0.001), had similar Glasgow Coma Scale scores (p = 0.12) and more often presented in a coagulopathic state (p < 0.001). Patients following MVC had higher rates of ICU admission and spent longer in hospital.

Conclusions: MVC was the most common mechanism of isolated pediatric TBI requiring hospital admission and associated with significantly higher rates of ICU utilization and longer hospital length of stay. These findings highlight the urgent need for validation from other centers in the Kingdom of Saudi Arabia (KSA) and preventive strategies directed at pediatric occupants of motor vehicles in the KSA.

Keywords: Wounds and injuries, pediatrics, injuries, brain, road traffic crash, epidemiology, Saudi Arabia.

Introduction

Globally, road traffic deaths in children is estimated to occur in 10.7 per 100,000 population [1]. Motor vehicle crashes (MVC) are similarly a major cause of mortality, morbidity, and disability in the Kingdom of Saudi Arabia (KSA) with fatality rates due to MVC estimated to be double that of the USA [2,3]. Head trauma is considered to be the most common cause of mortality and morbidity among the pediatric population. Nationally, in the KSA, one third of pediatric trauma patients requiring hospital admission were due to head injury [4].

Head injury can lead to irreversible brain damage. Children are more liable to have head injury due to larger head sizes compared to body surface area [5] with increased morbidity compared to adults attributed to greater behavioral and cognitive limitations. In addition, children are variable in their development, behavior and response to traumatic insults, demanding complex management of head injury that requires individualized care for each patient.

There is paucity of literature on head injuries among children in the entire Gulf Cooperation Council countries including Saudi Arabia. Such studies are essential to address areas requiring improvement in prevention and management for better support and outcome in pre-hospital and in-hospital care, rehabilitation and

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psychological effects after trauma. The aim of this study was to report the burden of isolated pediatric traumatic brain injury (TBI) at a major trauma center in Riyadh, Saudi Arabia and assess associations with mechanism of injury. Specifically, we aimed to describe the demographics, mechanisms and hospital outcome of admitted pediatric patients with TBI presenting to a tertiary hospital in KSA. In particular, the association of motor vehicle crashes (MVC) with isolated traumatic brain injury was explored.

Methods

Setting

Riyadh, the capital city of the KSA has a population of approximately 8 million according to the latest national census, with 34% of the population within the pediatric age group (<14 years old) [6]. In Riyadh, there are 16 governmental hospital, of which 8 receive trauma patients. All of them accommodate pediatric trauma patients and are serviced by pediatric intensive care unit (ICU). During the time of our study, child restraint systems were not compulsory in the KSA. There was no regulation or enforcement of child-specific restraints in motor vehicles in the KSA. As such, the prevalence of child-specific restraints use in Riyadh is low, and such safety devices have been reported to be seldom used [7].

This study analyzed data from the King Saud Medical City (KSMC)—a tertiary care center in Riyadh for medicine and surgery especially spinal and neurosurgery. It has 1,500 beds of which 180 beds are in the ICU. By virtue of the bed capacity and patient load, KSMC is by far the largest hospital of Saudi Arabia. KSMC's Emergency Department (ED) is one of the busiest in the country with over 140,000 visits per year, of which over 80,000 are for pediatric patients. There are 210 pediatric-specific beds at KSMC. All pediatric trauma cases are admitted and managed with adults in the trauma ward for multi-trauma, and for isolated trauma, such as isolated TBI, pediatric patients are admitted with adult patients under the specific subspecialty caring for such trauma; for example, a child with isolated traumatic brain injury is admitted under neurosurgery in neurosurgery ward. However, if requiring critical care, patients are admitted to the Pediatric Intensive Care Unit, that has 12 critical beds and 8 step-down beds.

Study design

This was a retrospective cohort study with inclusion criteria of all pediatric patients presenting after trauma and admitted to the KSMC-Trauma center from January 1, 2016 to December 31, 2017 and who were diagnosed with isolated TBI. Patients were included regardless of the severity or mechanism of their brain injury. Patients with injury to other body regions of abbreviated injury scale > 2 were excluded. All consecutive patients that met the above inclusion criteria were identified through the KSMC-medical records, ED registry data and ICU data were included. MVC as the mechanism of injury was the primary exposure variable. These included occupants of motor vehicles only and not pedestrians. Data extracted included variables pertaining to demographics, mechanisms of injury, initial vital signs, pathology and radiological findings, ICU utilization and mortality at hospital discharge. Data were extracted by investigators using explicit chart review, reviewed by a second investigator and cross checked against abstracted data for accuracy. The Glasgow Coma Scale (GCS) score was recorded prior to any sedatives. For patients <4-year old, a pediatric specific GCS was used. Coagulopathy was defined as INR>1.3 on first sample of blood test in the ED [8].

Statistical analysis

Exposure variables associated with pediatrics TBI were described using mean (standard deviation) for normally or near normally distributed continuous variables and compared using Student's *t*-test. Ordinal and skewed variables were summarized using median (inter-quartile range) and compared using Wilcoxon Rank-Sum test. Count variables were expressed as proportions and compared using the chi-square test or Fisher's Exact test if value in a cell was <5. A p-value of <0.05 was defined as statistical significance. Univariable associations with ICU utilization were assessed using logistic regression analysis and presented using odds ratio (95% confidence intervals). Stata v.15.1 (College Station, TX) was used for statistical analyses.

Results

During the study period, 2,501 pediatric patients presented to the ED with head injury and 241 were admitted with isolated TBI (Figure 1). The sample consisted of predominantly male patients, (n = 166; 66%), and the mean age was 6.7(3.9) years. Overall, MVC was the leading cause of TBI with (n = 142; 59%) patients, followed by falls (n = 68; 28.2%), pedestrian (n = 26; 10.8%) and non-accidental injury (n = 5; 2.1%). Most (n = 185, 76.8%) of the patients were transported to hospital by ambulance.

The associations between demographic variables and mechanism of injury of MVC are listed in Table 1, demonstrating that children with TBI following MVC were older than children injured by other mechanisms. In addition, patients with trauma due to MVC more often presented in a coagulopathic state and lower GCS scores.

ICU utilization of patients following MVC were higher with 102(63.7%) admitted to the ICU compared to 58(36.2%) patients injured through other mechanisms (p = 0.03). ICU admission was not associated with age (OR 1.05; 95% CI: 0.98–1.12), male sex (OR 0.87; 95% CI: 0.49–1.51), being of Saudi Arabian nationality (OR 0.88; 95% CI: 0.62–1.24), presenting heart rate (OR 1.01; 95% CI: 0.99–1.02). ICU admission was significantly associated with presentation after a MVC (OR 1.80; 95%

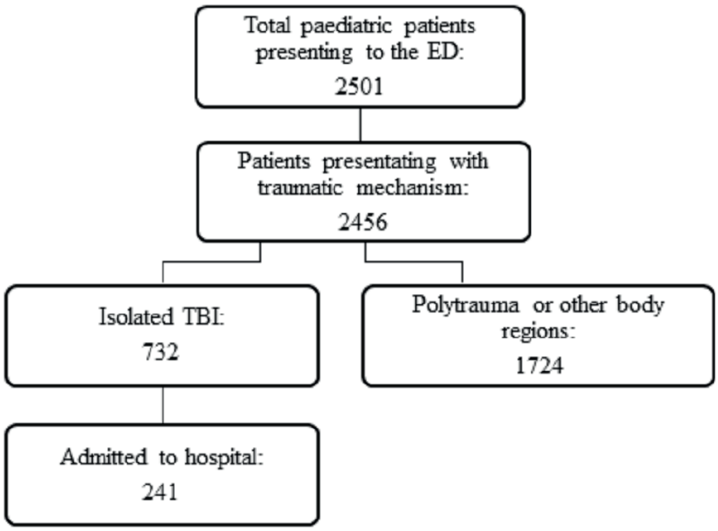

Figure 1. *Selection of patients.*

Table1. *Association between demographic variables and mechanism of injury of RTC*

	RTC (n=142)	Non-RTC (n=99)	p-value
Age	7.4 (3.7)	5.7 (4.1)	0.001
Male sex	93(65.5%)	49(49.5%)	0.72
Initial HR (b/min)	115.6 (20.0)	116.5 (26.6)	0.76
Initial SBP (mmHg)	99.9 (21.9)	98.5 (18.9)	0.61
GCS: - 3-8 - 9-12 - 13-15 - Missing	 22 72 45 3	 14 39 44 2	0.12
Initial pH	7.30 (0.10)	7.32 (0.10)	0.18
Initial pCO2 in mmHg	44.3 (10.2)	43.2 (11.3)	0.46
Initial HCO3 in mEq/L	21.3 (4.5)	21.4 (3.7)	0.95
Initial platelet count $\times 10^3$/ml	295.3 (115.8)	335.6 (113.7)	0.06
Initial INR	2.4 (1.6)	2.0 (1.5)	0.12
Coagulopathy	85(59.9%)	35(35.3%)	0.002

CI: 1.05–3.10), presenting with an initial lower systolic blood pressure (OR 0.98; 95% CI: 0.97–0.99), lower GCS (OR 0.30; 95% CI: 0.22–0.40), and being coagulopathic (OR 4.10; 95% CI: 2.19–7.70).

Following MVC, patients spent 10(5–20) days in hospital, significantly longer than patients injured through other mechanisms of 6.5 (3–15) days ($p = 0.01$). There were 21 (8.7%) deaths at hospital discharge, 12 after MVC and 9 after other mechanisms ($p = 0.86$). The association between mechanism of injury, time of death, and hospital length of stay (LOS) are illustrated in Figure 2, demonstrating similar times to death from MVC versus other injuries.

Discussion

In this single center study from the Kingdom of Saudi Arabia, the most common mechanism of isolated pediatric TBI requiring hospital admission was MVC with about two-thirds of patients injured by MVC and requiring admission managed in the pediatric ICU. To the best of authors' knowledge, this is the first study reporting on pediatric head trauma in a major hospital setting that represent a large population of children in Riyadh, Saudi Arabia with a complete data set.

The epidemiology of isolated pediatric TBI in the KSA was found to be different to other centers in the region. In Africa and Asia, pedestrians were most commonly injured in MVCs, while vehicle occupants were more likely involved in reports from Australia, Europe and the USA [9]. Among reports from Asia, falls are usually reported to be the most common mechanism of pediatric TBI [10]. This highlights an unique feature of TBI epidemiology in the KSA and was consistent with previous reports from the KSA supporting a majority of

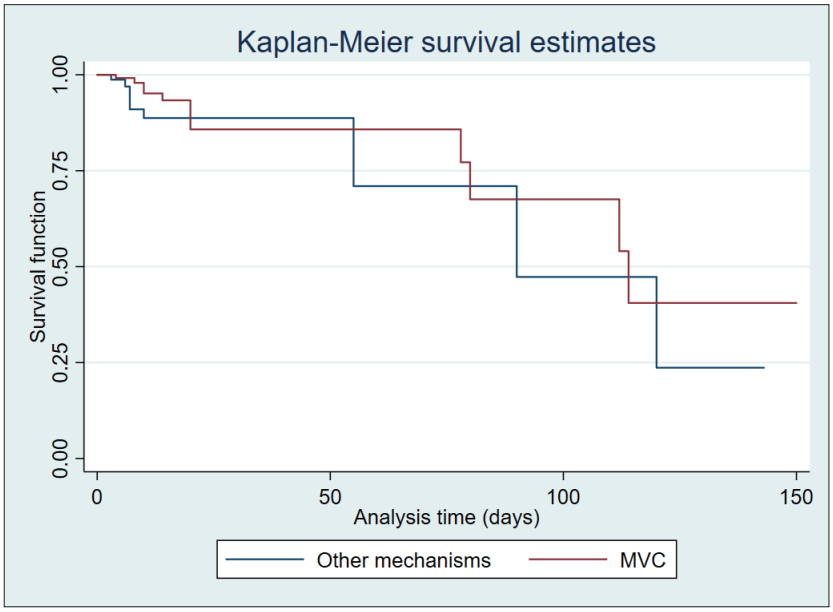

Figure 2. *Time to death of included patients.*

head injuries to be secondary to MVC [4,11]. Consistent with the mechanism of injury, pediatric TBI secondary to MVC was mostly among the older age group, most of them being male, which is similar to the other national and international observational reports [9–12].

There were no statistically significant differences observed among distribution of severity of TBI as defined by initial GCS. This is in contrast to other regional reports such as in South Tunisia where the main cause of TBI is MVC (69.4%), and among those, GCS was significantly low, on average of 8+/−3.[13] This suggests an effective pre-hospital system in the KSA where patients are transported to the trauma center based on mechanism of injury and not on presenting physiological variables only.

The higher rates of ICU admission after MVCs have been previously reported [14–19] and were confirmed by our study. Additionally, we demonstrated the expected derangements in physiological variables and lower GCS, most likely a marker of severity of head injury, to be associated with ICU admission.

Hospital mortality after isolated TBI in this single center was higher than reported from centers in Australia, the USA and the UK that reported mortality rates among pediatric TBI to be less than 1% [20–22]. A key feature in the presenting clinical variables in our setting was higher rate of coagulopathy. It has been demonstrated that TBI appears to be the common trigger of trauma induced coagulopathy and mortality in children. Although, the mechanism still not well understood, traumatized brain tissue has been associated with both a combination of both hypo-hypercoagulable states [23,24]. It is possible that secondary to developing hemostatic systems in this age group, coagulopathy may have a disproportionately adverse effect in pediatric TBI compared to adult population [25].

These findings highlight the need for introduction of novel child safety laws that would mandate the use of age-specific restraints for all passengers. Broader interventions of speed control and road conditions are also suggested. In addition, this study highlights priorities for assessment of patients with TBI including detection and management of coagulopathy. The prediction of coagulopathy and use of point of care tests for measurement has the potential to improve outcome in this cohort of patients.

This study was limited in being a retrospective analysis with associated bias of obtaining data through medical records. However, we identified the complete set of subjects during the study period, and this center represents a large population of children in Riyadh. Patients with isolated TBI only were included and while highlighting the substantial burden, grossly underestimates the burden on TBI among pediatric patients in the KSA. This study did not assess existing preventive strategies, such as child restraint systems and airbags, and the pre-hospital care measures that are important aspects of resuscitation and management and potentially associated with outcomes, as such data were poorly documented in medical records.

Conclusions

Approximately, two-thirds of pediatric isolated TBI in this large tertiary referral hospital in the KSA were secondary to MVC. Most cases required management in pediatric ICU setting and a high mortality rate was observed. Prevention of head injury presents the most successful management modality to avoid morbidity. Future studies should focus on validation of the results in other centers in the KSA and implementation of preventive strategies and safety measures with surveillance of outcomes focused towards reduction of pediatric TBI.

List of Abbreviations

ED	Emergency Department
GCS	Glasgow Coma Scale
TBI	Traumatic brain injury
ICU	Intensive Care Unit
KSA	Kingdom of Saudi Arabia
KSMC	King Saud Medical City
MVC	Motor vehicle crash

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Consent for publication

The requirement to seek informed consent from patients was waived by the ethics committee.

Ethics approval

This study was reviewed by the KSMC Institutional Review Board and approved (Approval no. H1RI-13Nov17-03).

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