

The spectrum and outcome of paediatric traumatic brain injury in KwaZulu-Natal Province, South Africa has not changed over the last two decades

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Objectives. This retrospective review of a prospectively entered and maintained hybrid electronic trauma registry was intended to develop a comprehensive overview of traumatic brain injury (TBI) in children and adolescents and to compare it with previous audits from our local environment and from other developing world centres. All TBI patients admitted to hospital were included in this study. We reviewed the age, gender, outcomes, radiological findings and treatment of the patients.

Methods. All patients aged ≤ 18 years old who were admitted by the Pietermaritzburg Metropolitan Trauma Service (PMTS) with TBI between December 2012 and December 2016 were included in this audit.

Results. During the 4-year period under review, a total of 563 children and adolescents were treated for TBI by the PMTS. The median age was 6.4 years and 29% ($n=165$) were females. The mechanism of TBI was blunt trauma in 96% ($n=544$) of cases, with 4% ($n=19$) suffering penetrating trauma. The penetrating mechanisms included impalement by a cow horn and miscellaneous injuries due to saws, axes, barbed wire, spades, stones and knives. The blunt mechanisms included falls ($n=102$), assaults ($n=108$), collapse of a building ($n=28$), bicycle-related injury ($n=14$), falling off a moving vehicle ($n=280$), motor vehicle accident (MVA; $n=59$), pedestrian vehicle accident (PVA; $n=183$) and animal-related injuries ($n=8$). There were 454 (80%) mild, 67 (12%) moderate and 42 (7%) severe cases of TBI. A total of 48 patients were admitted to the intensive care unit and 23 were admitted to the high care unit. Nine patients died. All the deaths were in the MVA and PVA group. The spectrum of TBI as diagnosed on computed tomography scans was nonspecific cerebral contusion ($n=92$), depressed skull fracture ($n=70$), sub-arachnoid haemorrhage ($n=60$), extradural haemorrhage ($n=41$), intracerebral haemorrhage ($n=19$), free air ($n=19$), subdural haemorrhage ($n=13$), intraventricular haemorrhage ($n=9$). A total of 62 (11%) patients required surgery.

Conclusion. There is a significant burden of paediatric TBI in Pietermaritzburg. The majority of TBI was related to blunt trauma and assaults were very common. Although the short-term outcomes are good, the long-term consequences are poorly understood. Injury prevention programmes are needed to help reduce this burden of disease and a nationwide trauma registry is long overdue.

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Trauma, particularly traumatic brain injury (TBI), is increasingly recognised as a major global public health problem, which is on par with infectious diseases and cardiac disease. A public health problem demands a co-ordinated multi-faceted response from a diverse group of stakeholders.^[1-10] South Africa (SA) has successfully mounted such a response to the HIV/AIDS pandemic and has, within a decade, rolled back the situation from one of abysmal and apocalyptic proportions to the management of a widespread chronic disease like diabetes. Hopefully, with continued intervention and the potential development of a vaccine, HIV/AIDS may ultimately be consigned to the history books. This remarkable achievement was based on a solid knowledge base generated by numerous clinical audits that accurately described and quantified the situation as it existed in the field. However, globally it would appear that in contrast to other public health problems such as cardiac diseases and infectious diseases, TBI has not been subject to adequate investigation or surveillance.^[11-18] SA, with its excessive trauma burden, is typical in this regard. There is no national trauma registry to track the epidemic in general and there are only a handful of local reports and audits which document the situation as it pertains to TBI in SA.^[11-15] In addition, there are specific vulnerable population groups such as women, children and

adolescents which have been inadequately investigated. TBI is an epidemic that is largely ignored, despite being reported on. This is problematic as it is difficult to motivate politically for resources, programmes and legislation to address these problems without a solid knowledge base.

This study was a retrospective review of a prospectively entered and maintained hybrid electronic trauma registry,^[16] which aimed to describe the incidence and outcomes of TBI among children and adolescents so as to develop a comprehensive overview of TBI in this population and to compare it with previous audits from SA.^[11-18] It is hoped that this audit will provide useful data to the various stakeholders who need to come together to combat this neglected epidemic.

Methods

The city of Pietermaritzburg is the capital of KwaZulu-Natal Province (KZN) and is the largest city in the western half of KZN. Approximately 1 million people reside in the city. The Pietermaritzburg Metropolitan Trauma Service (PMTS) maintains a prospective digital registry, which captures data on all surgical admissions. All surgical patients who require admission or transfer to a higher level of care are entered

into this database. This includes patients admitted for neurological observations and neurological protection, patients requiring urgent transfer to the neurosurgical unit, as well as those requiring long-term admission for rehabilitation. Approval to maintain the registry has been obtained from the Biomedical Research Ethics Committee (ref. nos BCA221/13 and BE 207/09 BREC) of the University of KwaZulu-Natal and from the Research Unit of the Department of Health. The digital registry is unique and has been discussed in the literature.^[16] The clerking medical staff enter the data into an electronic pre-prepared clerking sheet. This process is the clerking process for all new admissions so the clinical data are entered in real time. As the data are entered, they are directly incorporated into the registry. The completed pre-prepared clerking sheet is then printed and becomes the patient's clinical record. At operation and on discharge a similar process is followed. This system combines the functions of a medical registry and a medical record system. It also combines an electronic system with a paper-based system and has been called the Hybrid Electronic Medical Registry. The data entry is strictly quality controlled by the staff of the PMTS using a process of daily review and weekly morbidity and mortality meetings.^[16]

All patients aged ≤18 years, who were admitted with TBI during the period December 2012 to December 2016, were included in the audit. Basic demographic data, vital signs on arrival, physical examination findings and Glasgow Coma Scale (GCS) were recorded. In accordance with advanced trauma life support, the conventional severity of TBI grading based on GCS was used: mild (13 - 15), moderate (9 - 12) and severe (3 - 8) TBI. Final clinical outcomes were reviewed and were recorded as either survival or death. In the event of patient survival, the best GCS on discharge was noted.

Statistical analysis

Data were entered into an Excel spreadsheet and analysed using Stata 13.0 (StataCorp, USA). We generated basic descriptive statistics to describe the cohort of patients. Continuous variables were summarised using mean and standard deviation (SD) values and median (interquartile range (IQR)) values were presented in cases where there was evidence of skewing or asymmetrical outliers. We attempted to analyse trends in admission related to the following variables: nature of injury, mortality rate, number of admissions annually, age, sex, and mechanism of injury.

Results

During the 4-year period under review, a total of 563 children and adolescents were treated for TBI by the PMTS. The median age was 6.4 years and 29% (n=165) were female. In 96% (n=544) of cases, the mechanism of TBI was blunt trauma, with 4% (n=19) sustaining penetrating trauma. The penetrating mechanisms included impalement with a cow horn, as well as injuries sustained by a saw, an axe, barbed wire, a spade, stones and knives. The blunt mechanisms included falls (n=102), assaults (n=108), collapse of a building (n=28), bicycle-related injury (n=14), fall off a moving vehicle (n=280), motor vehicle accident (MVA; n=59), pedestrian vehicle accident (PVA; n=183) and animal-related (n=8) injuries. The average age according to the mechanism of trauma is shown in Table 1 and Fig. 1. The breakdown of GCS on admission is shown in Table 2. Of the cases, 80% (n=454) were mild, 12% (n=67) were moderate, and 7% (n=42) were severe TBI cases. A total of 48 patients were admitted to the intensive care unit and 23 were admitted to the high care unit. Nine patients died. All the deaths were in the MVA and PVA group.

The spectrum of TBI as diagnosed on computed tomography scan (Fig. 1) was intracerebral contusion (this is a broad term and includes

Table 1. Age v. mechanism of injury

Mechanism	Age (years), median (IQR)
CS	3 (0.2 - 10)
Fall	3 (0.2 - 15)
BAI	5.5 (3 - 10)
FFH	5.5 (0 - 17)
FDS	7*
PVA	6 (0 - 17)
FFMV	8 (2 - 16)
MVA	9 (0 - 17)
FFB	11.5 (8 - 16)
Assault	15 (0 - 17)
PI	15 (1 - 17)

CS = collapsing structure; BAI = blunt animal injury; FFH = fall from height; FDS = fall down stairs; PVA = pedestrian vehicle accident; FFMV = fall from moving vehicle; MVA = motor vehicle accident; FFB = fall from bicycle; PI = penetrating injuries. *One case recorded.

Table 2. Glasgow Coma Scale (GCS) score on admission v. mortality

GCS on admission	Total (N=563), n (%)	Survived (N=554), n (%)	Died (N=9), n (%)
<4	7 (1.2)	4 (0.7)	3 (33.3)
5	9 (1.6)	7 (1.3)	2 (22.2)
6	16 (2.8)	14 (2.5)	2 (22.2)
7	5 (0.9)	5 (0.9)	0
8	5 (0.9)	5 (0.9)	0
9	18 (3.2)	18 (3.3)	0
10	11 (2.0)	11 (2.0)	0
11	20 (3.6)	18 (3.3)	2 (22.2)
12	18 (3.2)	18 (3.3)	0
13	17 (3.0)	17 (3.0)	0
14	43 (7.6)	43 (7.8)	0
15	394 (70.0)	394 (71)	0

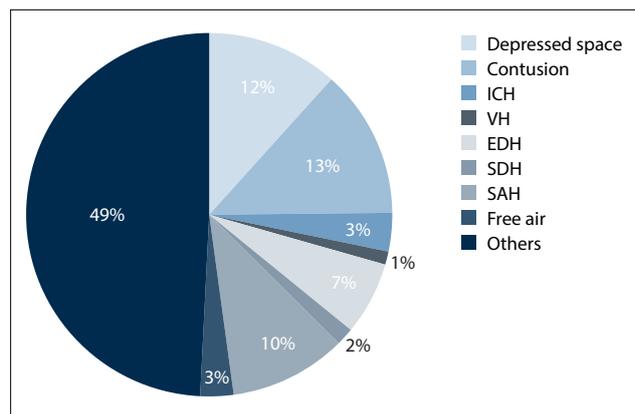


Fig. 1. Injuries sustained by the study population (%). (ICH = intracerebral haemorrhage; VH = ventricular haemorrhage; EDH = extradural haemorrhage; SDH = subdural haemorrhage; SAH = sub-arachnoid haemorrhage.)

the frontal, parietal, temporal and occipital contusions) (13.0%, n=92), depressed skull fracture (11.7%, n=70), sub-arachnoid haemorrhage (10.4%, n=60), extradural haemorrhage (6.5%, n=41), intracranial haemorrhage (3.4%, n=19), free air (2.9%, n=19), subdural haemorrhage (1.5%, n=13), intraventricular haemorrhage (1.1%, n=9). A total of 62 (10.6%) patients required surgery and were referred to our neurosurgical centre. The operations needed

included cranioplasty (n=2), craniotomy (n=28), debridement (n=3), decompressive craniotomy (n=7), shunt (n=2), and washout (n=1).

Discussion

The centre in SA that has most consistently reported on paediatric TBI is the Red Cross War Memorial Children’s Hospital in Cape Town. A series of reports over the last four decades reveal an epidemic of TBI in children which has been largely ignored.^[9-14] Table 3 compares the data from these studies. Our data were similar to those reported from these earlier SA studies.^[9-14] In keeping with these reports, the predominant mechanism of TBI in children was blunt trauma. However, the high incidence of assault as a mechanism of blunt trauma reflects the high level of interpersonal violence which is the norm in SA.^[1-9] There were different injury patterns according to age. Falls seem to occur in the age range of 6 - 8-years-old. From the age of 11 years onwards, bicycle-related injuries become more common. The incidence of assault and penetrating trauma begins to increase in the older age groups as children approach adolescence and early adulthood (Table 1). The most common injuries are depressed skull fractures or intracerebral contusions, followed by sub-arachnoid haemorrhage. Discreet space-occupying lesions such as an extradural or subdural haematoma are less common.^[1-8] The need for neurosurgical intervention was low (3.4%). Only a small subset of patients required formal neurosurgical intervention and the vast majority were managed by general surgeons and intensivists. The mortality rate was 3.6%. The data from these series are remarkably similar to our current series and demonstrate that little has changed since the turn of the millennium in terms of paediatric TBI management in SA as a whole, and in KZN in particular.

In a recent global review, investigators evaluated 165 000 children who had sustained a TBI across five continents.^[9] Our results are broadly in keeping with this global survey. As we have shown, there is a male predominance especially in children older than three. A bimodal age distribution is often described, with very young children (0 - 2 years) and adolescents^[16-19] being more commonly injured. In our study, mild TBI (GCS ≥13) constituted >80% of injuries and only

~10% of patients needed an operation. The major mechanisms of injury in children were falls and motor vehicle collisions. However, in the developing world children are more frequently pedestrian victims than passengers. Non-accidental trauma is a common cause of paediatric TBI in both the developing and developed world. Outcomes for TBI in children are by and large good.^[9,11-15] Mortality was associated with low GCS on admission and was confined to the MVA and PVA cohorts. However, this gives a false sense of the severity of TBI. The effects of a TBI in a child may be long-term and may impact on the child’s future ability to work and earn a salary.

Study limitations

The lack of a proper classification of the severity of the injury based on computed tomography scan findings^[17] was a limitation; however, it should provide an impetus for efforts to develop a nationwide trauma registry.^[18,9]

Conclusion

One of the key components in the systematic response to trauma is the development of a trauma system with dedicated trauma centres.^[18-20] The huge burden of trauma in SA is overwhelming and requires a co-ordinated public health-based response. This response must combine curative efforts with prevention strategies.^[1-9] Primary prevention also needs to be emphasised. Based on this and other SA audits, we need to address the issues of vehicle-related injuries and interpersonal trauma. Some risk factors can be addressed by improved vehicle safety as well as by the introduction of traffic calming zones around schools and public places. Dealing with the issue of intentional trauma in children is more challenging.

There is a significant burden of paediatric TBI in Pietermaritzburg. The majority of TBI was related to blunt trauma and assaults were very common. Although the short-term outcomes were good, the long-term consequences are still poorly understood. Despite a number of reports on TBI, the epidemic is largely ignored and prevention programmes are needed to help reduce this burden of disease. A nationwide trauma registry is long overdue.

Table 3. Comparative data from similar studies

	Present study (Buitendag <i>et al.</i>)	Kihurani <i>et al.</i> ^[21]	Schrieff <i>et al.</i> ^[15]	Okyere- Dede <i>et al.</i> ^[11]	Laloo and van As ^[14]	Semple <i>et al.</i> ^[13]	Kibel <i>et al.</i> ^[22]	Knobel <i>et al.</i> ^[23]
Year	2017	2014	2013	2013	2004	1998	1990	1984
N	563	4 690	137	506	37 610	102	5 468	1 820
Age, median (years)	6.4	6.3	6.1	6	4.9	ND	4.9	ND
Male (%)	71	63	65	65	59	56	ND	67
Cause of TBI (%)								
MVA	10	28	21	63	6.5	0	11.4	48
PVA	33	71	55	0	12.2	83	0	0
Assault	19	0	0.7	23	13.1	0	0	8.5
Falls	18	0	5	5	41.2	11	43.4	31
Other mechanisms	20	1	18.3	9	27	6	45.2	12.5
Severity (%)								
Mild	81	58	ND	ND	ND	ND	ND	ND
Moderate	12	37	ND	ND	ND	ND	ND	ND
Severe	7	5	ND	ND	ND	100	ND	ND
Outcome (%)								
Conservative management	89	0	0	96	96.4	91.2	0	0
Surgical management	11	0	0	4	3.6	8.8	0	0
Mortality	1.5	0.6	14.6	3.6	0.2	57	0	4.2

ND = not determined; TBI = traumatic brain injury; MVA = motor vehicle accident; PVA = pedestrian vehicle accident.

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