S Afr J Surg. 2022;60(4):273-277
https://doi.org/10.17159/2078-5151/SAJS3599

S Afr J Surg
ISSN 038-2361

TRAUMA

Factors influencing the outcomes of patients with severe traumatic brain injury following road traffic crashes

AGM Groshi, B Enicker

Department of Neurosurgery, Inkosi Albert Luthuli Central Hospital, University of KwaZulu-Natal, South Africa

Corresponding author, email: *aalgroshi@yahoo.com*

Background: Traumatic brain injury (TBI) is one of the leading causes of mortality and morbidity in South Africa. Road traffic crashes (RTCs) are among the commonest aetiology of TBI in South Africa. This study aimed to determine the factors influencing the outcomes in patients with severe TBI following RTCs.
Methods: A retrospective study was conducted of patients who were admitted to the neurosurgery department at Inkosi Albert Luthuli Central Hospital between January 2013 and December 2017 with TBI following RTCs and with a Glasgow Coma Scale (GCS) < 9. Demographic, clinical, and radiological information was obtained. The outcome at discharge was categorised into favourable and unfavourable, using the Glasgow outcome score. Statistical analysis was performed to determine factors contributing to the outcome.
Results: The study population consisted of 100 patients. The mean age was 29.5 ± 14.1 years old (range 3–81 years). The majority of patients (85%) were males. Pedestrian vehicle accidents accounted for 46%, compared to motor vehicle collisions (54%). The mean hospital stay duration was 14.2 ± 8.8 days (range 1–43 days). The median post-resuscitation GCS was 6 (range 3–8), (p = 0.52). Fifty-two patients had an unfavourable outcome compared to 48 who had a favourable outcome. Eleven patients presented with pupillary abnormalities (p = 0.88), which included unilateral dilated non-reactive (DNR) pupil in seven patients, whilst four patients had bilateral. Five patients developed refractory intracranial hypertension (RIC-HTN), all these patients had unfavourable outcomes, (p = 0.03). Thirty-eight patients developed systemic hypotension (SBP < 90 mmHg), 32 out of these patients had unfavourable outcomes (p < 0.001). In female patients, 80% had unfavourable outcomes compared to 47% of male patients (p = 0.02). Extracranial injuries were diagnosed in 50 patients, and 24 patients had unfavourable outcomes (p = 0.42).
Conclusion: The outcomes in patients with severe TBI following road traffic crashes are influenced by hypotension (SBP < 90 mmHg), RIC-HTN and female gender, which have a negative influence on outcomes.
Keywords: road traffic crashes, TBI, outcome, intracranial hypertension

Introduction

Traumatic brain injury (TBI) is a significant cause of death, disability and socioeconomic problems worldwide and is often called the 'silent epidemic'.[1-3] The estimated incidence of TBI worldwide is 939 per 100 000. Nell and Brown, in 1991, estimated the incidence of TBI in South Africa (SA) to be 316 per 100 000 population per year.[4-6]

In SA, the majority of RTCs are preventable and are mainly due to human, vehicle and road infrastructure factors. The environmental factors are often beyond the control of the driver. RTCs impose a significant burden on the SA economy. In 2015, it was reported that the cost of RTCs was estimated at R 143 billion, equating to 3.4 % of the GDP of SA.[7]

National road safety strategies have been implemented by the South African government to help reduce RTCs.[8-11] The aim of this study was to determine the factors influencing outcomes in patients with severe TBI following RTCs referred and managed at a provincial referral neurosurgery department in the province of KwaZulu-Natal.

Materials and methods

Study population

This was a retrospective, descriptive and analytical study of patients who were admitted to the neurosurgery department (ND) at Inkosi Albert Luthuli Central Hospital (IALCH) with a diagnosis of severe TBI (Glasgow Coma Scale [GCS] < 9) following RTCs. The study period was between January 2013 to December 2017.

Data collection

Data collected included demographics (age and gender), mechanism of injury (MOI), post-resuscitation GCS at the primary hospital, pupillary size and reactivity, associated extracranial injuries and length of stay (LOS) in the ND. We further described laboratory results and pathology found in radiological investigations such as CT brain scan. Patients with incomplete medical, radiological and laboratory records were excluded.

Outcomes

The Glasgow outcome scale (GOS), a standardised scale used to determine and document the outcome of patients after sustaining a TBI, was used. The scale has 5 categories: 1 – death; 2 – persistent vegetative state; 3 – severe disability; 4 – moderate disability; 5 – good recovery. In this study, the outcomes were categorised into favourable (GOS 4–5) and unfavourable (GOS 1–3).

Statistical analysis

Mean and standard deviation were used for categorical variables. Statistical analyses were performed using the chi-square/Fisher's exact test (association between categorical variables and the outcome) and the two-samples Wilcoxon rank-sum (Mann–Whitney) test. We considered $p < 0.05$ as statistically significant.

Results

A total of 100 patients diagnosed with severe TBI following RTCs were recruited into the study. Forty-eight had a favourable outcome while 52 had an unfavourable outcome (Table I).

Age and gender

The mean age was 29.5 ± 14.1 years (range 3–81 years). The age categories of the patients with severe TBI are shown in Table II. The majority (85%) of patients were male. The mean age was 30 ± 13.8 years in the favourable group compared to 28.2 ± 15.6 years in the unfavourable group ($p = 0.68$) (Table II).

Mechanisms of injury

Pedestrian vehicle collisions (PVC) constituted 46% of the injuries, whereas motor vehicle collisions (MVC) represent 54%. The mean age was 27.7 ± 14.9 years in the PVG group compared to 32.2 ± 14.4 years in the MVC group ($p = 0.66$) (Table II).

GCS on admission

All patients were intubated and ventilated on arrival. The median post-resuscitation GCS score was 6. The range of post-resuscitation GCS score for both groups was 3–8 ($p = 0.52$) (Table II).

Pupillary size and reflex

Fifty-two patients were recorded to have normal pupillary size on admission, while seven patients presented with a unilateral dilated non-reactive (DNR) pupil and four with bilateral DNR pupils. Thirty-seven patients had pinpoint pupils due to sedation (Table II).

Table I: The Glasgow outcome scale of patients with severe traumatic brain injury following RTCs

Score	Outcome	*n*
5	Good recovery	40
4	Moderate	8
3	Severe disability	5
2	Persistent vegetative state	30
1	Death	17
	Total	**100**

Associated extracranial injuries

Fifty patients had associated extracranial injuries. These included extremities (24), chest (21), abdominal injuries (12), facial bone fractures (12) and cervical spine fractures (5) (Table III).

CT scan findings

CT scan findings included cerebral contusion/intracerebral haematoma (ICH) in 48 patients, acute subdural haematoma (42), cerebral swelling (33), epidural haematoma (8) and skull fractures (24).

Surgical interventions

Seventy-six patients underwent intracranial pressure (ICP) monitor insertion, craniotomy (29) and decompressive cra-

Table II: A comparison of patients with favourable and unfavourable outcomes

Factor	Favourable outcome (*n* = 48)	Unfavourable outcome (*n* = 52)	*p*-value
Age groups			
< 18 years	10	13	0.68
18–45 years	32	35	
> 45 years	6	4	
Sex			
Male	45	40	0.02
Female	3	12	
Mechanisms of injury			
PVA	21	25	0.66
MVC	27	27	
GCS score			0.52
3 points	9	7	
4 points	2	4	
5 points	6	5	
6 points	10	13	
7 points	18	15	
8 points	3	8	
Pupillary size and reflex			
Reactive	25 23	27 25	0.99
Non-reactive Both DNR Unilateral DNR	 2 4	 2 3	 0.88
Coexistence of extracranial injuries			
Yes	26	24	0.42
No	22	28	
RIC-HTN			
Yes	0	5	0.03
No	48	47	
Hypotension (SBP < 90 mmHG)			
Yes	6	32	< 0.001
No	42	20	

MVC – motor vehicle collisions, PVA – pedestrian vehicle accidents, GCS – Glasgow Coma Scale, DNR – dilated non-reactive, RIC-HTN – refractory intracranial hypertension

Table III: Associated extracranial injuries

Area of injuries	*n*
Upper limbs	
• Radio-ulnar fracture	7
• Humerus fracture	2
Lower limbs	
• Femur fractures	6
• Tib-fib fracture	9
Chest injuries	
• Ribs-fracture with lung contusion	21
Cervical spine fractures	5
Abdominal injuries	
• Splenic injury	8
• Kidney injury	4
Facial bone fractures	12

niectomy (15). Decompressive craniectomy was primary in seven (47%) and secondary in eight (53%) patients. Tracheostomy was performed in 30 patients due to prolonged intubation.

Complications

Pneumonia was reported in 27 patients, the majority cultured *Acinetobacter baumannii* (59%), followed by *Pseudomonas aeruginosa* (26%) and *Klebsiella pneumoniae* (15%) as shown in Figure 1.

Meningitis was diagnosed in six patients, and organisms cultured from cerebrospinal fluid (CSF) were *Escherichia coli* (3), *Staphylococcus aureus* (2), and *Proteus mirabilis* (1). Wound sepsis was diagnosed in three patients and organisms cultured were *Staphylococcus auricularis* (1) and *Staphylococcus aureus* (1). The culture was negative in the third patient.

Outcomes

The mean hospital duration stay was 14.2 ± 8.8 days (range 1–43 days). Five patients developed refractory intracranial hypertension (RIC-HTN), had decompressive craniectomy to control RIC-HTN; all five patients had an unfavourable outcome. Thirty-eight patients were diagnosed with hypotension (SBP < 90 mmHg) and 32 (84 %) of them had unfavourable outcomes (Table II).

Discussion

In this study looking at outcomes of patients with severe TBI following RTCs, we found that 48% of the patients had a favourable outcome while 52% had an unfavourable outcome. Previous South African research showed that the range of favourable outcomes among patients with severe TBI ranges from 28.2–60%,[11,12] which is worse than in high-income countries.[12,13]

The majority of the patients in this study were young adults in the age group 15–45 years, similar to what has been found elsewhere.[14] However, we did not notice significant differences between the various age groups and the outcome. The findings of Gómez et al. showed that unfavourable outcome rate increases significantly over 35 years of age and is 10 times higher in patients older than 65 years when compared to those aged 15–25 years.[15] On the other hand, Heiskanen and Sipponen noted that 60 years is the critical threshold and is associated with worsening of the outcome,[16]

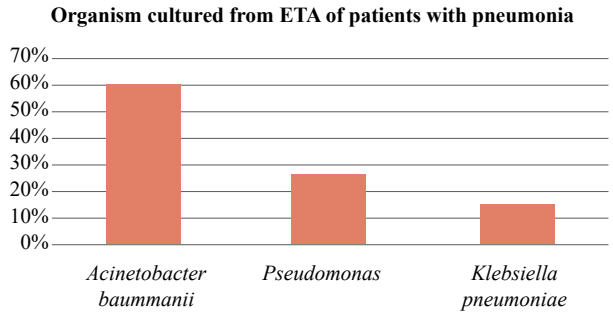

Figure 1: Organisms cultured from endotracheal aspiration (ETA) of patients with pneumonia

probably due to the decreased capacity of the adult brain for recovery due to decreasing number of functioning neurons and greater exposure to subclinical insults.

Some authors have pointed to the existence of a difference in the prognosis of traumatic patients based on gender, as women have worse clinical outcomes compared to men.[17,18] In our study, we found that 80% of female patients had an unfavourable outcome compared to 40% of male patients. The reason for differences in the outcome between females and males after severe TBI remains inconclusive, and further study is needed to elucidate the reasons. It should also be noted that there was a small sample size of women in our study.

Concerning injury mechanisms, we found that MVC represents 54%, while PVA accounts for 46% of all RTCs. When comparing the two groups, the age distribution with pedestrians tends to be slightly younger than the MVC group. However, we did not observe any statistical differences in terms of the outcome between the two groups. This contrasts with previous studies which reported that pedestrians are a highly vulnerable population group among motor-vehicle trauma patients, with higher mortality compared to motor vehicle occupants.[19,20] This discrepancy could be explained by the idea that compliance with safety restraint measures such as using the seat belt, child restraint, and driving slowly is low among car occupants and motorcyclists in SA, resulting in severe TBI and high percentage of an unfavourable outcome.

At admission, 67% and 33% of patients had GCS 6–8 and 3–5 respectively. The role of GCS in deciding the outcome was studied in previous studies and noted that low GCS was correlated with poor outcomes.[21,22] However, in this study, we could not find a linear association between GCS and the outcome, as patients with GCS scores (6–8) had similar outcome to GCS scores (3–5). The confounding factors are patients being referred to the ND following necessary administration of multiple medications, such as powerful sedatives and analgesics, during the resuscitation process, which interferes with the assessment of GCS. In addition to that, in patients presenting with hypotension and extracranial injuries, additional medical and other measures taken to address these issues may further interfere with the assessment, which ultimately affects accurate scoring of the GCS at admission.

In TBI patients, clinical evaluation of the pupil is very important, and variation in pupillary size and pupillary reflex at different points after injury could be very helpful in determining the prognosis, as pupil abnormalities are correlated with unfavourable outcome.[22,23] However, when

we examined the relationship between the pupils and the functional outcome, we did not find significant differences between normal and abnormal pupils. The difference between our results and previous results could be related to the frequent difficulties in examining the pupil's size and its reactively appropriately due to different factors such as facial trauma and grossly periorbital swelling which might ultimately lead to inaccurate assessment of pupil size and its reactivity.

The effect of extracranial injuries on the outcome of patients with TBI has been questionable. We found that 50% of our patients with TBI had extracranial injuries. However, our results show that in comparing the two groups, the presence of extracranial injuries may not have a sufficient impact on a significant increase in mortality and morbidity. This is in agreement with the study by Sarrafzadeh et al.[24] and Watanabe et al.[25] who did not find significant differences in the mortality rate between TBI patients with extracranial injuries compared to TBI patients without extracranial injuries. However, Marappan et al. found that the presence of other major traumatic injuries, along with severe head injury, contributed to poor outcome among patients.[26]

The present study found that patients who developed RIC-HTN (which is defined as an increase in ICP that is not controlled with maximal medical treatment) and hypotension (SBP < 90 mmHg) had an unfavourable outcome. It has been documented in the literature that RIC-HTN and hypotension are associated with an unfavourable outcome.[27-29]

Study limitations

The main limitations of our study are the retrospective nature, which makes it inherently vulnerable to bias, the fact that data has been collected by various individuals over a wide range of time, which could affect data quality, as well as the relatively limited sample size, which might influence the statistical significance.

Conclusion

The outcomes in severe TBIs following RTCs are influenced by different factors. In this study, we found that RIC-HTN (SBP < 90 mmHg) and female gender worsened the outcomes.

Improving the outcomes requires good resuscitation, high standards of intensive care and efficient health systems which enable early referral to a neurosurgical unit for definitive management. A multidisciplinary team of clinicians, researchers, and policymakers is required; in addition, public awareness campaigns on road safety rules are needed to help minimise TBI following RTC.

Acknowledgements

I would like to acknowledge the assistance Dr W Sibanda (biostatistician), the support from my supervisor Mr B Enicker (HOD Neurosurgery), and Miss C Samuel for her technical help.

Conflict of interest

The authors declare no conflict of interest.

Funding source

No funding was required.

Ethical approval

Ethical approval was obtained from the Biomedical Research Ethics Committee at the University of KwaZulu-Natal. Ref No: BE047/18 (Substudy of BCA 219/15).

ORCID

AGM Groshi https://orcid.org/0000-0001-8162-5640
B Enicker https://orcid.org/0000-0003-1285-3046

REFERENCES

1. Dewan MC, Rattani A, Gupta S, et al. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018;130(4):1080-97. https://doi.org/10.3171/2017.10.JNS17352.
2. Iaccarino C, Carretta A, Nicolosi F, Morselli C. Epidemiology of severe traumatic brain injury. J Neurosurg Sci. 2018;62(5):535-41. https://doi.org/10.23736/S0390-5616.18.04532-0.
3. Hyder AA, Wunderlich CA, Puvanachandra P, Gururaj G, Kobusingye OC. The impact of traumatic brain injuries: a global perspective. NeuroRehabilitation. 2007;22(5):341-53.
4. Nell V, Brown DSO. Epidemiology of traumatic brain injury in Johannesburg – II. Morbidity, mortality and aetiology. Soc Sci Med. 1991;33(3):289-96. https://doi.org/10.1016/0277-9536(91)90363-H.
5. World Health Organization. Road traffic injuries 2020. Available from: https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries.
6. World Health Organization. Global status report on road safety 2018: summary. Geneva: World Health Organization; 2018 (WHO/NMH/NVI/18.20). Available from: https://www.who.int/violence_injury_prevention/road_safety_status/2018/en/.
7. National Road Safety Strategy 2016-2030. Available from: https://www.gov.za/documents/national-road-safety-strategy-2016-2030-22-may-2017-0000.
8. Parkinson F, Kent S, Aldous C, Oosthuizen G, Clarke D. Road traffic crashes in South Africa: the burden of injury to a regional trauma centre. S Afr Med J. 2013;103(11):850-2.
9. Rimel RW, Jane JA, Edlich RF. An injury severity scale for comprehensive management of central nervous system trauma. J Am Coll Emerg Physicians. 1979;8(2):64-7. https://doi.org/10.1016/S0361-1124(79)80039-8.
10. González-Robledo J, Martín-González F, Moreno-García M, Sánchez-Barba M, Sánchez-Hernández F. Prognostic factors associated with mortality in patients with severe trauma: from prehospital care to the intensive care unit. Med Intensiva. 2015;39(7):412-21. https://doi.org/10.1016/j.medin.2014.06.004.
11. Hofman K, Primack A, Keusch G, Hrynkow S. Addressing the growing burden of trauma and injury in low- and middle-income countries. Am J Public Health. 2005;95(1):13-17. https://doi.org/10.2105/AJPH.2004.039354.
12. Maasdorp SD, Swanepoel C, Gunter L. Outcomes of severe traumatic brain injury at time of discharge from tertiary academic hospitals in Bloemfontein. Afr J Thoracic Crit Care Med. 2020;26(2):32-35. https://doi.org/10.7196/AJTCCM.2020.v26i2.057.
13. Sobuwa S, Hartzenberg HB, Geduld H, Uys C. Predicting outcome in severe traumatic brain injury using a simple prognostic model. S Afr Med J. 2014;104(7):492-4. https://doi.org/10.7196/SAMJ.7720.
14. Perel P, Arango M, Clayton T, et al. Predicting outcome after traumatic brain injury: practical prognostic models

based on large cohort of international patients. BMJ. 2008;336(7641):425-9. https://doi.org/10.1136/bmj.39461.643438.25.
15. Gómez PA, Lobato RD, Boto GR, et al. Age and outcome after severe head injury. Acta Neurochir. 2000;142:373-80. https://doi.org/10.1007/s007010050445.
16. Heiskanen O, Sipponen P. Prognosis of severe brain injury. Acta Neurol Scand. 1970;46(3):343-8. https://doi.org/10.1111/j.1600-0404.1970.tb05798.x.
17. Farace E, Alves WM. Do women fare worse: a meta analysis of gender differences in traumatic brain injury outcome. J Neurosurg. 2000;93(4):539-45. https://doi.org/10.3171/jns.2000.93.4.0539.
18. Kirkness CJ, Burr RL, Mitchell PH, Newell DW. Is there a sex difference in the course following traumatic brain injury? Biol Res Nurs. 2004;5(4):299-310. https://doi.org/10.1177/1099800404263050.
19. Reith G, Lefering R, Wafaisade A, et al. Trauma Register DGU. Injury pattern, outcome and characteristics of severely injured pedestrian. Scand J Trauma Resusc Emerg Med. 2015;23(1):56. https://doi.org/10.1186/s13049-015-0137-8.
20. Olukoga A. Pattern of road traffic accidents in Durban municipality, South Africa. West Afr J Med. 2008;27(4):234-7.
21. Kung WM, Tsai SH, Chiu WT, et al. Correlation between Glasgow coma score components and survival in patients with traumatic brain injury. Injury. 2011;42(9):940-4. https://doi.org/10.1016/j.injury.2010.09.019.
22. Emami P, Czorlich P, Fritzsche FS, et al. Impact of Glasgow coma scale score and pupil parameters on mortality rate and outcome in paediatric and adult severe traumatic brain injury: a retrospective, multicentre cohort study. J Neurosurg. 2017;126(3):760-7. https://doi.org/10.3171/2016.1.JNS152385.
23. Marmarou A, Lu J, Butcher I, et al. Prognostic value of the Glasgow coma scale and pupil reactivity in traumatic brain injury assessed pre-hospital and on enrolment: an IMPACT analysis. J Neurotrauma. 2007;24(2):270-80. https://doi.org/10.1089/neu.2006.0029.
24. Sarrafzadeh AS, Peltonen EE, Kaisers U, et al. Secondary insults in severe head injury – do multiply injured patients do worse? Crit Care Med. 2001;29(6):1116-23. https://doi.org/10.1097/00003246-200106000-00004.
25. Watanabe T, Kawai Y, Iwamura A, et al. Outcomes after traumatic brain injury with concomitant severe extracranial injuries. Neurol Med Chir. 2018;58(9):393-9. https://doi.org/10.2176/nmc.oa.2018-0116.
26. Marappan K, Prabhu M, Balasubramani K, Raj SP. Factors influencing outcome in head injury patients with Glasgow coma scale < 8. Apollo Medicine. 2017;14(4):207-11.
27. Marmarou A, Anderson RL, Ward JD, et al. Impact of ICP instability and hypotension on outcome in patients with severe head trauma. J Neurosurg. 1991;75(Suppl):S59-S66. https://doi.org/10.3171/sup.1991.75.1s.0s59.
28. Spaite DW, Hu C, Bobrow BJ, et al. The effect of combined out-of-hospital hypotension and hypoxia on mortality in major traumatic brain injury. Ann Emerg Med. 2017;69(1):62-72. https://doi.org/10.1016/j.annemergmed.2016.08.007.
29. Hutchinson PJ, Kolias AG, Timofeev IS, et al. Trial of decompressive craniectomy for traumatic intracranial hypertension. N Engl J Med. 2016;375:1119-30. https://doi.org/10.1056/NEJMoa1605215.