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ORIGINAL ARTICLE

What intracranial pathologies are most likely to receive intervention? A preliminary study on referrals from an emergency centre with no on-site neurosurgical capabilities

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A B S T R A C T

Introduction: Access to neurosurgical facilities remains limited in resource-restricted medical environments worldwide, including Africa. Many hospitals refer patients to off-site facilities if they require intervention. Unnecessary referrals, however, can be detrimental to the patient and/or costly to the healthcare system itself. The aim of this study was to determine the frequency and associated intracranial pathology of patients who did and did not receive active neurosurgical intervention after having presented to an academic emergency centre at a hospital without on-site neurosurgical capabilities.
Methods: A one-year, retrospective record review of all patients who presented with potential neurosurgical pathology to a tertiary academic emergency centre in Johannesburg, South Africa was conducted.
Results: A total of 983 patients received a computed tomography brain scan for suspected neurosurgical pathology. There were 395 positive scans; 67.8% with traumatic brain injury (TBI) and 32.3% non-traumatic brain injury (non-TBI). Only 14.4% of patients received neurosurgical intervention, mostly non-TBI-related. The main intervention was a craniotomy for both TBI and non-TBI patients. The main TBI haemorrhages that received an intervention were subdural (SDH) (16.5%) and extradural (10.4%) haemorrhages. More than half the patients with non-TBI SDHs as well as those with aneurysms and subarachnoid haemorrhages received an intervention.
Discussion: Based on this study's findings, in a resource-restricted setting, the patients who should receive preference for neurosurgical referral and intervention are (1) those with intracranial haemorrhages (2) those with non-traumatic SDH more than traumatic SDH and (3) those patients with non-traumatic subarachnoid haemorrhages caused by aneurysms.

African relevance

- Access to neurosurgical facilities remains limited in resource-restricted countries; many hospitals do not have neurosurgical facilities on-site and patients in need, need to be transferred.
- Non-traumatic intracranial haemorrhages occur twice as much in low- and middle-income countries than in high-income countries; 89% of trauma related deaths occur in low- and middle-income countries.
- Referrals are often made unnecessarily and may lead to an increased burden on the healthcare system.

Introduction

The global burden of disease study from 2010 confirmed that trauma is the leading cause of disability and mortality. Of these trauma-related deaths, 89% occurred in low- and middle-income countries (LMICs) [1,2].

Neuro-trauma registries from high-income countries indicate that approximately 5.3 million people in the United States of America and 7.7 million people in Europe live with traumatic brain and spinal cord injury-related disabilities. Traumatic brain injuries (TBIs) are mostly caused by road traffic incidents and also affect older population groups [1]. Due to a lack of formal trauma registries in LMICs, especially neuro-trauma, incidence rates for TBIs are likely underestimated. However, TBI occurs more often in young adults due to the higher frequency of road traffic incidents (both pedestrian and motorist) as well as inter-personal violence

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in this cohort [1]. The incidence is also increasing due to the increased use of motor vehicles in LMICs [3].

The majority of neurosurgical research has been conducted in high-income countries. Evidence-based recommendations from this research may not always be transferable to LMICs due to the lack of well-funded and well-equipped neurosurgical facilities. Even amongst different LMICs, what may be a priority in one country may not be a priority for another [1].

Common haemorrhages that are non-traumatic in origin include intracranial (ICH) and subarachnoid (SAH) haemorrhages. Intracranial haemorrhages affect approximately 24.6 per 100,000 people per year and have a high mortality rate of up to 52%. They occur twice as often in LMICs than in high-income countries. Risk factors include ethnicity (higher in Black race group), hypertension, the use of anticoagulants, high alcohol intake and drug abuse (most notably, cocaine) [4,5].

Non-traumatic SAH are caused by a ruptured aneurysm 80–85% of the time [4,6,7]. This occurs in around 9–20 people per 100,000 per year. Similar to ICH, the leading risk factors include a history of smoking, alcohol and/or drug use, as well as the presence of hypertension. Female sex as well as a family history of cerebrovascular disease has also been associated with increased risk of aneurysm development [4,6–8].

In 1991, a study by Nell et al. found an incidence of 319 head injuries per 100,000 people per year in South Africa, which is double the rate for other developing countries (150–170 per 100,000) [9,10]. These figures are presumably even higher now as the incidence of homicide and road traffic incidents in South Africa are on the increase [11].

Based on 1998 statistics in a 2009 article, Taira et al. noted that access to neurosurgical procedures is very limited in sub-Saharan Africa, providing less than one neurosurgeon for every 6.4 million inhabitants [12]. South Africa is the exception with 212 registered neurosurgeons for a population of just under 55 million people (1:265,507), a ratio that has improved since 2013 (1:280,220), but which is still low compared to a ratio of 1:61,000 in the United States of America [13–15].

Even though South Africa has more neurosurgeons available than the rest of sub-Saharan Africa, numerous hospitals, including tertiary ones, do not have neurosurgical facilities on-site and patients in need of neurosurgical intervention need to be transferred to a referral hospital [10,16]. In 2007, Ashkenazi et al. assessed the effectiveness of teleradiology from a level two emergency centre that did not have neurosurgical services. They found that with a reliable system in place, strict patient selection criteria and committed staff members, teleradiology could be effective in reducing unnecessary transfers [17]. In Canada, a centralised, web-based teleradiology system was instituted called ENITS (the Emergency Neuro-Image Transfer System). Referring hospitals were able to send emergency computed tomography brain (CTB) images to ENITS where they could be accessed and viewed by the on-call neurosurgeon [18].

Despite the close proximity of our referral hospitals' Neurosurgical Department, the transfer of neurosurgical patients remains a challenge due to resource limitations. The aim of this study was to determine the frequency and associated intracranial pathologies of patients who did and did not receive active neurosurgical intervention after having presented to an academic Emergency Centre (EC) at a hospital with no on-site neurosurgical capabilities.

Methods

This was a one-year, retrospective record review of all patients who presented with potential neurosurgical pathology to a tertiary academic EC in Johannesburg, South Africa from 1 January to 31 December 2012. The EC receives approximately 60,000 patient visits per annum. Neurosurgical coverage is provided by the Department of Neurosurgery at another tertiary hospital, eight kilometers away. In the study EC, patients are evaluated and if indicated by their history and physical findings, a CTB is performed. Neurosurgery referrals are made telephonically – the necessary information is relayed to the neurosurgeon who then in turn either accepts or declines the transfer.

This research was approved by the Human Research Ethics Committee of the Faculty of Health Sciences of the University of the Witwatersrand [M121177]. Potential patients for inclusion were identified through the EC patient registers as well as the radiology department records of patients who were referred from the EC for a CTB. The files of these patients were then retrieved from the records department and the data captured by a single researcher. The records of the patients transferred to the referral hospital were also obtained and reviewed. Patients' demographic details, aetiology, CTB results, transfer information and neurosurgical interventions were extracted from the records. Descriptive statistics were used to analyse the data.

Results

A total of 983 patients received a CTB for suspected neurosurgical pathology comprising of 697 (70.9%) males and 286 females. Of those, 395 (40.2%) were positive for pathology and discussed with neurosurgery. The male to female ratio for TBIs was 7.7:1, and for non-TBI 1:1.7. The age range was 12–91 years old (mean 35.6 years old). Table 1 shows the breakdown of the patients who had pathology on their CTB where neurosurgery was consulted.

No neurosurgical intervention was performed on 91.4% of patients with TBI and 73.2% of non-TBI patients. The aetiologies of TBI were interpersonal violence (n = 114; 42%), road traffic incidents (n = 91; 34%), falls (n = 30; 11%) and sports injuries (n = 2; 1%). Mechanism of injury was not documented in 31 cases (12%).

Fig. 1 demonstrates the types and frequencies of the common neurosurgical procedures performed on the TBI and non-TBI patients.

Tables 2 and 3 summarise both traumatic and non-traumatic intracranial pathologies as well as the interventions that were performed.

Discussion

Almost 1000 patients with potential neurosurgical pathologies presented to the study EC in one year with just over one patient per day having significant pathology that required neurosurgical consultation. However, only one third of all patients with pathology were transferred with a minority of those patients receiving an intervention. The bulk of patients presenting to the EC with

Table 1
Summary of neurosurgical consultations and interventions.

	TBI n (%)	Non-TBI n (%)	Total n (%)
Discussed with Neurosurgery	268 (67.8)	127 (32.2)	395
No transfer	208 (77.6)	67 (52.8)	275 (69.6)
Transfer & return	18 (6.7)	3 (2.4)	21 (5.3)
Transfer & conservative management	14 (5.2)	13 (10.2)	27 (6.8)
Transfer & intervention*	23 (8.6)	34 (26.8)	57 (14.4)
No transfer/no intervention due to death/refused treatment	4 (1.5)	9 (7.1)	13 (3.3)
Insufficient information	1 (0.4)	1 (0.8)	2 (0.5)

TBI, traumatic brain injury.
* n = 3 of these patients died during the interventions (all craniotomies).

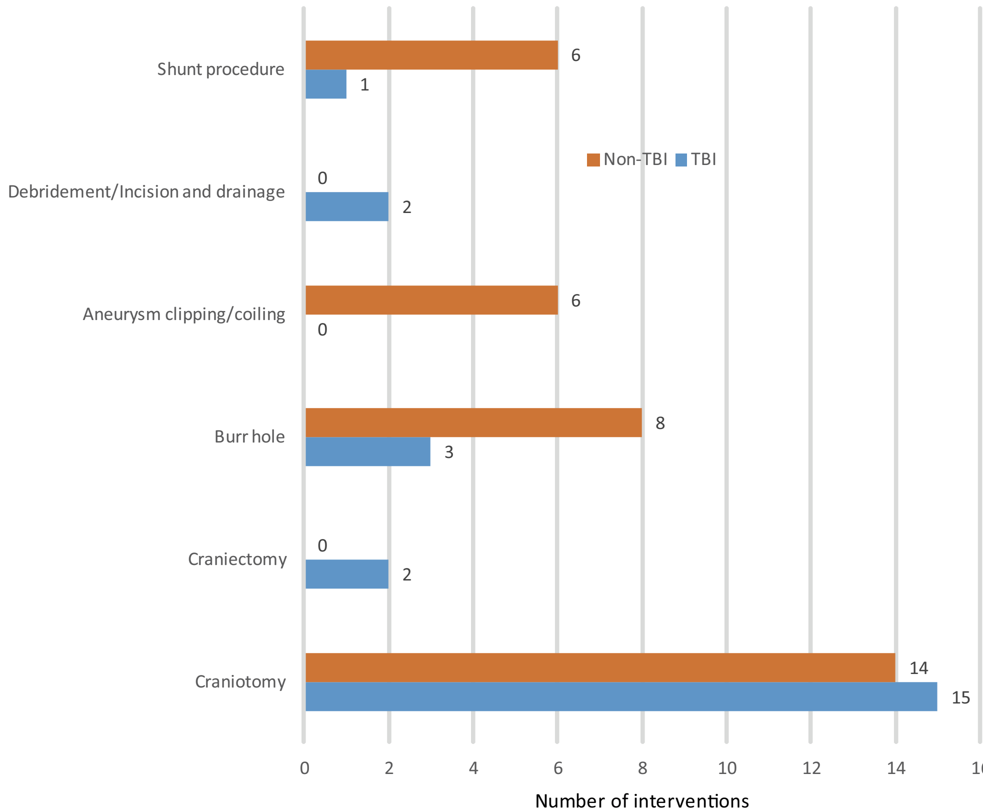

Fig. 1. Types of neurosurgical interventions (TBI, traumatic brain injury).

Table 2
Traumatic brain injuries: intracranial pathologies and their corresponding interventions.

Intracranial pathologies*	Total TBI pathologies	Crani-otomy	Crani-ectomy	Burr hole	Debridement/ I&D	VP shunt/EVD insertion	Total pathologies receiving interventions
ICH	47	2 (4.3)	1 (2.1)	0	0	1 (2.1)	4 (8.5)
SDH	91	11 (12.1)	1 (1.1)	3 (3.3)	0	0	15 (16.5)
SAH	91	3 (3.3)	1 (1.1)	1 (1.1)	0	0	5 (5.5)
EDH	48	3 (6.3)	0	0	0	1 (2.1)	5 (10.4)
DAI	8	0	0	0	0	0	0
Raised ICP	36	3 (8.3)	1 (2.8)	1 (2.8)	0	1 (2.8)	6 (16.7)
Pneumocephalus	17	0	0	0	0	0	0
Hydrocephalus	11	0	0	1 (9.1)	0	0	1 (9.1)
Cerebral oedema	22	1 (4.5)	1 (4.5)	0	0	0	2 (9.1)
Midline shift	37	4 (10.8)	2 (5.4)	1 (2.7)	0	0	7 (18.9)
Contusion	90	4 (4.4)	1(1.1)	0	0	0	5 (5.6)
Skull fractures	92	4 (4.3)	2 (2.2)	0	0	0	6 (6.5)
Sinus and facial fractures	27	1 (3.7)	0	0	0	0	1 (3.7)
Abscess/ring enhancing lesion	2	0	0	0	1 (50.0)	0	1 (50.0)
Other**	7	2 (28.6)	0	0	1 (14.3)	0	3 (42.9)

TBI, traumatic brain injury; ICH, intracerebral haemorrhage; SDH, subdural haemorrhage; SAH, subarachnoid haemorrhage; EDH, extradural haemorrhage; DAI, diffuse axonal injury; ICP, intracranial pressure; I&D, incision and drainage; VP, ventriculoperitoneal; EVD, external ventricular drain.
* Most patients had more than one intracranial pathology.
** Includes foreign body *in situ*, blocked VP shunt, basal ganglia bleed and lobe wall lesions.

neurosurgical pathology were secondary to trauma, however, the patients with non-trauma-related pathologies were three times more likely to receive a neurosurgical intervention than the TBI patients. The ultimate outcomes of these patients, whether they received interventions or not, were not documented making it impossible to draw conclusions with regards to the success or failure of interventions and/or the effects of the transfer itself. These findings echoed that of Alexander et al. who recorded interpersonal violence and road traffic incidents as their major TBI causes in a regional hospital in Kwazulu-Natal, South Africa [10]. Other causes for TBIs included falls and sports injuries, which is congruent with previous literature from other LMICs [1,10].

SDH and EDH were the most common haemorrhages amongst patients with TBIs. Patients with isolated diffuse axonal injury and/or a pneumocephalus never received any neurosurgical intervention and therefore would have no need for referral in a resource-restricted environment. However, in the non-TBI group, more than half the patients with SDHs received an intervention, making them three times more likely than a patient with a TBI-related SDH to receive a surgical intervention.

Table 3
Non-traumatic brain injuries: intracranial pathologies and their corresponding interventions.

Intracranial pathologies	Total non-TBI pathologies	Crani-otomy	Burr hole	Aneurysm clipping/coiling	VP shunt/EVD insertion	Total pathologies receiving interventions
ICH	44	0	0	0	1 (2.3)	1 (2.3)
SDH	23	7 (30.4)	5 (21.7)	0	0	12 (52.2)
SAH	30	0	0	5 (16.7)	0	5 (16.7)
Aneurysm	10	0	0	6 (60.0)	0	6 (60.0)
EDH	1	0	0	0	0	0
Raised ICP	18	1 (5.6)	1 (5.6)	0	1 (5.6)	3 (16.7)
Hydrocephalus	25	1 (4.0)	1 (4.0)	0	4 (16.0)	6 (24.0)
Cerebral oedema	4	0	0	0	0	0
Midline shift	20	0	1 (5.0)	0	1 (5.0)	2 (10.0)
Meningitis/abscess/ring enhancing lesion	8	0	3 (37.5)	0	0	3 (37.5)
Tumour	15	7 (46.7)	0	0	0	7 (46.7)
Other*	12	0	0	0	1 (8.3)	1 (8.3)

TBI, traumatic brain injury; ICH, intracerebral haemorrhage; SDH, subdural haemorrhage; SAH, subarachnoid haemorrhage; EDH, extradural haemorrhage; ICP, intracranial pressure; VP, ventriculoperitoneal; EVD, external ventricular drain.
* Includes foreign body *in situ*, blocked VP shunt, basal ganglia bleed and lobe wall lesions.

Unnecessary referrals may lead to an increased burden on an already strained healthcare system [17]. Patients who were returned by the referring hospital without having any neurosurgical intervention may have been unnecessarily exposed to the potential harms of inter-hospital transfers such as displacement of an endotracheal tube and pressures sores as well as the preventable associated costs. The crude referral procedure itself could account for this – CTB images were forwarded to the on-call neurosurgeon using the WhatsApp messaging service. The images together with the brief history from a telephonic consult formed the basis of the decision whether to transfer the patient. A more formal procedure and teleradiology system such as ENITS may be a way to avoid these unnecessary transfers [18].

In 2013, Borczuk et al. suggested criteria that patients with mild head trauma and intracranial haemorrhage needed to meet in order to bypass the need for neurosurgical consultation and/or intervention. These indicators included patients with isolated SAH, patients with a Glasgow Coma Scale of 15/15, no clinical deterioration and no change in the result of the follow-up CTB [19]. The criteria provided by Borczuk et al. could unfortunately not be compared to our results as the Glasgow Coma Scale data was not available retrospectively and none of our TBI patients had isolated SAHs.

This was a retrospective, single centre audit where patient outcomes were not documented making it impossible to draw conclusions with regards to the success or failure of interventions and/or non-interventions. The Glasgow Coma Scale data of the patients was not available and therefore could not be used to fully evaluate if it was a factor to determine whether a patient received an intervention or not. In a resource-restricted setting, if only one neurosurgical bed is available and there are three patients with neurosurgical pathologies, which patient should be transferred as being the most likely to receive an intervention?

Based on our findings, patients with intracranial haemorrhages would be more likely to receive an intervention than patients with hydrocephalus, pneumocephalus, skull fractures and cerebral oedema. A patient with a non-traumatic SDH would be more likely to receive an intervention than one with an SDH that is traumatic in origin. Patients with non-traumatic SAHs caused by aneurysms and SDHs would be more likely to receive an intervention than other types of haemorrhages.

Neurosurgical referrals and associated patient outcomes need to be assessed in a prospective study in order to create a clinical decision rule to determine appropriate referrals in this resource-restricted environment.

Conflicts of interest

The authors declare no conflict of interest.

Dissemination of results

Results from this study was shared with Hospital management.

Authors' contributions

LG and CB conceived the original idea. CB collected the data. LM and LG carried out the analysis of the data and drafted the manuscript. LG, CB and LM approved the final version that was submitted.

References

[1] Rubiano AM, Carney N, Chestnut R, et al. Global neurotrauma research challenges and opportunities. Nature 2015;527:S193–7. doi: http://dx.doi.org/10.1038/nature16035.
[2] Norton R, Kobusingye O. Injuries. N Engl J Med 2013;368:1723–30. doi: http://dx.doi.org/10.1056/NEJMra1109343 [PMID: 23635052].
[3] Maas AIR, Menon DK, Lingsma HF, et al. Re-orientation of clinical research in traumatic brain injury: report of an international workshop on comparative effectiveness research. J Neurotrauma 2012;29:32–46. doi: http://dx.doi.org/10.1089/neu.2010.1599 [PMID: 21545277].
[4] Caceres JF, Goldstein JN. Intra-cranial hemorrhage. Emerg Med Clin North Am 2012;30:771–94. doi: http://dx.doi.org/10.1016/j.emc.2012.06.003 [PMID: 22974648].
[5] Goldstein J, Gilson A. Critical care management of acute intracerebral hemorrhage. Curr Treat Options Neurol 2011;13:204–16. doi: http://dx.doi.org/10.1007/s11940-010-0109-2 [PMID: 21222062].
[6] Suarez JI. Diagnosis and management of subarachnoid hemorrhage. Continuum 2015;21(5):1263–87. doi: http://dx.doi.org/10.1212/CON.0000000000000217 [PMID: 26426230].
[7] D'Souza S. Aneurysmal subarachnoid hemorrhage. J Neurosurg Anesthesiol 2015;27:222–40. doi: http://dx.doi.org/10.1097/ANA.0000000000000130 [PMID: 25272066].
[8] Pare JR, Kahn JH. Basic neuroanatomy and stroke syndromes. Emerg Med Clin North Am 2012;30(3):601–15. doi: http://dx.doi.org/10.1016/j.emc.2012.05.004 [PMID: 22974640].
[9] Nell V, Brown DS. Epidemiology of traumatic brain injury in Johannesburg–II. Morbidity, mortality and etiology. Soc Sci Med 1991;33(3):289–96 [PMID: 1925693].
[10] Alexander T, Fuller G, Hargovan P, et al. An audit of the quality of care of traumatic brain injury at a busy regional hospital in South Africa. S Afr J Surg 2009;47(4):120–6 [PMID: 20141069].
[11] Naidoo D. Traumatic brain injury: the South African landscape. S Afr Med J 2013;103(9):613–4. doi: http://dx.doi.org/10.7196/SAMJ.7325 [PMID: 24300675].
[12] Taira BR, McQueen KAK, Burkle FM. Burden of surgical disease: does the literature reflect the scope of international crisis? World J Surg

2009;33:893–8. doi: http://dx.doi.org/10.1007/s00268-009-9981-x [PMID: 19290571].

[13] HPCSA iRegister. [Available from: http://isystems.hpcsa.co.za/iregister/] [Accessed 29 December 2016].

[14] Statistical Release P0302. Mid-Year Population Estimates 2015. Statistics South Africa. Available from: https://www.statssa.gov.za/publications/P0302/P03022015.pdf. [Accessed 29 December 2016].

[15] Overton TL, Shafi S, Cravens GF, et al. Can trauma surgeons manage mild traumatic brain injuries? Am J Surg 2014;208:806–10. doi: http://dx.doi.org/10.1016/j.amjsurg.2014.02.012 [PMID: 24933668].

[16] Zulu BM, Muluadzi TV, Madiba TE, Muckart DJ. Outcome of head injuries in general surgical units with an off-site neurosurgical service. Injury 2007;38(5):576–83. doi: http://dx.doi.org/10.1016/j.injury.2007.01.002 [PMID: 17472793].

[17] Ashkenazi I, Haspel J, Alfici R, et al. Effect of teleradiology upon pattern of transfer of head injured patients from a rural general hospital to a neurosurgical referral centre. Emerg Med J 2007;24(8):550–2. doi: http://dx.doi.org/10.1136/emj.2006.044461 [PMID: 17652675].

[18] eHealth Ontario [Internet]. Emergency Neurosurgery Image Transfer System now on-line in Timmins. Article from 12 November 2010. [Available from: http://www.ehealthontario.on.ca/en/news/view/emergency-neurosurgery-image-transfer-system-now-on-line-in-timmins] [Accessed 29 December 2016].

[19] Borczuk P, Penn J, Peak D, et al. Patients with traumatic subarachnoid haemorrhage are at low risk for deterioration or neurosurgical intervention. J Trauma Acute Care Surg 2013;74(6):1504–9. doi: http://dx.doi.org/10.1097/TA.0b013e31829215cf [PMID: 23694879].