A survey of adult patients requiring neurosurgery at a central hospital

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A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Medicine in the branch of Anaesthesiology.

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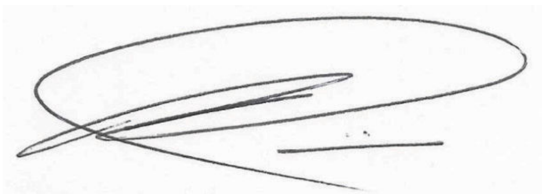
Declaration

I, Laura Indiveri declare that this research report is my own unaided work. It is being submitted for the Degree of Master of Medicine in the branch of Anaesthesiology at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



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Abstract

Background

Data pertaining to all subsets of neurosurgical patients admitted to South African hospitals is lacking. The aim of this study was to survey adult patients requiring neurosurgery at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Methods

A retrospective survey of the REDCap neuroanaesthesia database was conducted. Consecutive data were extracted for 2016 and 2017. Data described the pre-operative assessment, intra-operative anaesthetic management and post-operative status of patients undergoing elective and emergency neurosurgical procedures.

Results

The database entries of 873 patients were included in the study. Most of the patients, 622 (72.1%) were male, 558 (63.9%) received emergency surgery, and 337 (38.6%) patients had traumatic brain injury (TBI). The severe TBI incidence was 45.1%. The predominant anaesthetic technique was an intravenous propofol induction 629 (72.1%) and sevoflurane maintenance 539 (61.7%). Marked haemodynamic instability occurred in 208 (23.8%) patients, mandating either vasopressor 99 (47.6%) or inotropic 109 (52.4%) support. Seizure prophylaxis was only given to 39 (4.5%) patients. Steroids were administered to 134 (39.8%) TBI patients. Significantly more elective surgery patients, 224 (71.1%) were extubated immediately post-operatively ($p<0.0001$). However, the in-hospital mortality among patients did not differ significantly between those who had elective 30 (9.5%) or emergency surgery 47 (8.4%, $p=0.6697$). In-hospital mortality was higher for patients having cranial surgery 61 (9.0%) compared to spinal surgery 6 (6.4%), but this difference was not statistically significant ($p=0.3926$).

Conclusion

The frequent administration of steroids to TBI patients at CMJAH is concerning but highlights the importance of utilising databases for quality improvement purposes. The unexpected mortality finding in this study between elective and emergency cases may be explained by the higher ASA classification of elective patients. This study contributes to the understanding of neurosurgical patient peri-operative care.

Acknowledgements

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Abbreviations

ASA	American Society of Anesthesiologists™
CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
CNS	Central nervous system
ETT	Endotracheal tube
GCS	Glasgow Coma Scale
HIV	Human immunodeficiency virus
ICP	Intracranial pressure
ICU	Intensive care unit
LI	Laura Indiveri
NHLS	National Health Laboratory Services
PH	Permissive hypotension
SA	South Africa
SAH	Subarachnoid haemorrhage
SD	Standard deviation
TBI	Traumatic brain injury
TIVA	Total intravenous anaesthesia
USA	United States of America

Statement

The Research Report consists of a literature review, draft article, study proposal and appendices. The study proposal is included for background reference and is not for examination.

The formatting of this Research Report complies with the University of the Witwatersrand's Style Guide for Theses, Dissertations and Research Reports. The formatting of the draft article may differ from the author guidelines of the Southern African Journal of Anaesthesia and Analgesia, the journal to which it is intended to be submitted, in order to comply with the university's style guide.

Section 1: Review of the literature

1.1 Introduction

The Institute of Medicine (1) defines health care quality as “the degree to which health care services for individuals and populations increases the likelihood of desired health outcomes and are consistent with current professional knowledge …”. The field of neurosurgery is a speciality affiliated with high cost and expensive advanced technology (2). There is a need to establish a validated approach to measure the quality of neurosurgical care (3). There has been an increasing focus in the neurosurgical literature to explore suitable surrogate markers of the quality of care received by neurosurgical patients (4).

South Africa has a unique quadruple burden of disease profile. This encompasses human immunodeficiency virus and tuberculosis co-infection, other communicable diseases, non-communicable diseases, and trauma (5). There is limited literature evaluating the profile of neurosurgical patients in South Africa, however, a few examples exist. An outdated 1991, contextually relevant study reported an estimated incidence of traumatic brain injury (TBI) in Johannesburg of 316 per 100 000 person-years (6). The TBI characteristics of patients in a Pietermaritzburg study is a contemporary example (7). Regarding the paediatric population, the profile of patients at Red Cross War Memorial Children Hospital in Cape Town (8) and Inkosi Albert Luthuli Central Hospital in KwaZulu Natal have been described (9).

In South Africa, the move towards an increased emphasis on quality has been reflected in recent reforms. The National Development Plan identifies “quality health care for all” as a key priority (10). Stemming from this, the National Health Insurance plan intends on investing in quality improvement, cognisant that the quality of care provided in the public sector may be of concern (11). As such there is a direct imperative to strengthen quality measurement in South Africa (12). Databases are fundamental in validating the appropriateness of existing quality metrics as well as elucidating novel neurosurgical specific quality indicators (4).

Naidoo (12) noted in an editorial, “SA [South Africa] does not have a TBI databank, and contemporaneous studies on overall incidence and prevalence of TBI are lacking.” The author went on to comment, “SA needs improved and current TBI epidemiological data to develop protocols appropriate to our unique set of conditions …” (12). Data pertaining to all subsets of neurosurgical patients admitted to South African hospitals is lacking. Electronic databases have emerged as important mechanisms to define, measure, and promote health care quality (13-15).

The Charlotte Maxeke Johannesburg Academic Hospital REDCap neuroanaesthesia database was created with a view to record the anaesthetic details for all neurosurgical patients presenting to theatre at the hospital. The database includes data from 75 peri-operative variables. This literature review will address aspects of select database fields and will speak to the standard of neurosurgical care, and to relevant controversies within the neuroanaesthesia literature.

1.2 Demographics of neurosurgical patients

Neurosurgical patients are a heterogenous group with age, sex, and race predilection for a diverse array of neuropathologies (9, 16-24). Patient volumes differ by neurosurgical condition and global region (25). For descriptive purposes, neurosurgery can be broadly classified as either cranial or spinal surgery. Rock et al. (26), in a high-income setting, compared patients having cranial and spinal surgery and found significant differences in patient operative volume and demographic characteristics between the two groups. Spinal surgery (78.2%) accounted for a disproportionately larger patient volume compared to the number of cranial surgery (21.8%) patients. Spinal patients were more frequently male, >65 years old, white, overweight, and smokers (26).

In low-middle income countries, cranial surgery, performed either as an emergency or electively, is encountered more commonly (9, 18, 25, 27, 28). In Africa, ten conditions requiring operative management in order of clinical importance are TBI, hydrocephalus, intracranial infections, stroke, epilepsy, traumatic spinal injury, brain tumours, intracranial vascular abnormalities, neural tube defects, and spinal tumours (25). Hydrocephalus (9, 21), congenital abnormalities (18, 27), and epilepsy (23, 24) affect the paediatric population most commonly and will not be discussed further.

TBI is a worldwide health concern (16, 20, 29, 30). TBI is estimated to affect 69 million people globally per annum (20). Cross-continental analysis of TBI studies, including patients of all ages, showed an estimated incidence ranging from 69.4 per 100 000 population in the United States of America (USA) to 1750.0 per 100 000 population in New Zealand (16). In Africa, the estimated annual incidence of TBI, and traumatic spinal cord injury is expected to be 127.8 and 11.4 per 100 000 population, respectively (25). A South African TBI incidence rate of 316.4 per 100 000 person-years was shown in Johannesburg (6). A meta-analysis estimates the annual incidence rate of TBI in adolescents and adults to be 618.5 per 100 000 person-years (16). TBI affects predominantly young adult males (6, 7, 16, 28, 31-36).

Certain central nervous system (CNS) infections require surgical intervention for effective source control (37). Internationally, the mean age of patients with CNS infections is 35.8 years, with a female predominance of 1:1.7 (22). The annual incidence of CNS infections requiring operation in Africa is estimated to be 24.4 per 100 000 population (25). Africa has the highest incidence of tuberculosis-related CNS disease compared to other global regions (22). In South Africa, the incidence of intracerebral abscess was estimated to be 15.5 per 100 000 population for 1993 – 2011 (38). A meta-analysis showed that this incidence level is higher than most countries, including the West Indies, Saudi Arabia, Taiwan, and the USA, reporting incidences of 2.4, 3.6, 10.5, and 0.8 per 100 000 population, respectively (22). In South Africa, a high HIV prevalence in the general population may account for this discrepancy (39).

An estimated incidence rate of intracranial aneurysm of 49.4 per 100 000 person-years has been reported in a Korean population (40). The estimated annual incidence rate of aneurysmal rupture leading to subarachnoid haemorrhage (SAH) in the USA is 7.2 – 9.0 per 100 000 population (17). SAH reportedly accounts for

5% - 10% of strokes in the USA. Aneurysmal SAH in this population is more common in females and black patients with a relative risk of 1.7, and 1.5 for sex, and race, respectively (17). The United Kingdom shows a lower incidence of SAH, although this reflects the findings of a single-centre study and excluding clinically worse grades of SAH. The incidence of World Federation of Neurosurgical Societies grades I and II SAH admissions was 3.0 per 100 000 population in the United Kingdom. The mean age of patients was 53 years. Similar to USA findings, the British population was predominantly female (65.2%). At an academic hospital in Bloemfontein, 161 patients with aneurysmal SAH detected by digital subtraction angiography were described over a six-year period. The mean age of these patients was 45 years, and they were predominantly female (63.4%) (41).

A combined age-adjusted incidence of brain and spine tumours of 22.6 per 100,000 population in the USA has been reported (42). The incidence of all CNS tumour types is highest in adults with a mean age at diagnosis of 59 years (42). Children who present with brain or spinal tumours will most commonly have a malignant subtype (19). Males and white patients will also more commonly present with malignant tumours, compared with females and black patients (19). In Africa, the estimated annual incidence of brain, and spine tumours of 7.9, and 0.1 per 100 000 population, respectively, are expected (25). Tumours accounted for 6.5% of patient admissions in a Nigerian audit of neurosurgical cases (27). The latter study did not stratify demographic data according to underlying diagnoses.

The American Society of Anesthesiologists™ (ASA) Physical Status Classification system serves as a surrogate indicator for patient pre-operative morbidity status. Comparing cranial and spinal surgery patients in the Rock et al. (26) cohort, cranial surgery patients were mostly classed ASA III (54.9%), and spinal surgery patients were mainly classed ASA II (48.8%). Moreover, significantly more cranial patients (13.6%) were classed ASA IV, compared to spinal patients (3.4%, $p<0.001$) (26). Specifically, hypertension, followed by chronic obstructive pulmonary disease, were the most common comorbid conditions in both patient groups. Overall, long-standing comorbidities were reported more frequently in spinal surgery patients. Cranial surgery patients more commonly had disseminated cancer, a bleeding diathesis, or were ventilator-dependent prior to surgery. Evidence of sepsis was significantly more common in cranial surgery patients, with these patients having a six-fold increased risk of presenting to theatre with severe inflammatory response syndrome compared to spinal surgery patients. More cranial surgery (13.6%) was performed as an emergency procedure, compared to spinal surgery (2.7%).

The ASA status among glioblastoma patients undergoing cranial surgery in a German institution was 57.6% for ASA I and II and 42.4% for ASA III and IV combined (43). In a North American study, patients undergoing spinal fusion surgery were mostly classed ASA II (44.1%) and ASA III (50.4%) (44). The patients in the ASA class III group were more likely to be elderly, obese, diabetic, dyspnoeic, functionally dependent, use steroids, and have cardiac, respiratory, and renal comorbidities (44). Both the German (43) and North American (44) population groups did not include patients having emergency surgery. In a group of TBI patients for emergency cranial surgery, all enrolled patients were classed ASA I – II. A higher ASA class was not cited as an exclusion criterion for this study (45). The validity and reliability of utilising ASA classification in trauma patients have been questioned (46, 47).

1.3 The pre-operative neurological assessment

The Glasgow Coma Scale (GCS) is a ubiquitous clinical scoring system in the assessment of neurosurgical patients (48, 49). GCS is the most common clinical tool to classify TBI severity (50). TBI is classed as mild, moderate, and severe with corresponding GCS scores of 13 – 15, 9 – 12, and ≤8, respectively (50). Despite widespread use, there are certain caveats that need to be addressed. Firstly, a GCS-based TBI severity classification system is not universally adopted. Preceding the establishment of the Brain Trauma Foundation guidelines (51), earlier TBI studies would use non-standardised descriptive TBI classification systems based on mechanism of injury (28). This forms the greatest source of heterogeneity in meta-analyses of TBI studies (16). This is reflected by the large variation in TBI incidence within and across various global regions (16, 20).

Secondly, the use of alterations in GCS as a means to diagnose TBI impacts the ability to identify mild TBI as the GCS is often normal (16). This may be particularly important in settings where the potential for language barriers exist. Thirdly, confounders such as pain, intoxicants, and medications can cause alterations in brain function with or without brain injury, further complicating the interpretation of GCS assessments (16). Finally, an emerging concept expressed by contemporary TBI studies shows that TBI severity, as assessed by GCS is not predictive of outcomes (36, 52, 53). Suggested reasons for this observation include pre-hospital treatment obscuring admission GCS (28, 52, 54) and that the severity of TBI may fluctuate with time (53). International consensus regarding an alternative assessment tool is pending further enquiry (53).

1.4 The intra-operative anaesthetic management of neurosurgical patients

The use of total intravenous- and volatile-based anaesthetic techniques in neurosurgical patients

Deciding on which anaesthetic technique to employ is an important preliminary neuroanaesthetic consideration. There has been an ongoing debate regarding the superiority of total intravenous anaesthesia (TIVA) compared to a volatile-based anaesthetic technique in neurosurgical patients (55). The concerns surrounding this debate are three-fold. There is a need for rapid recovery following anaesthesia (56), stable haemodynamics with concurrent mitigation of raised intracranial pressure (ICP) (57), and finally, a theoretical concern that certain anaesthetic agents influence the dissemination of tumour cells during tumour resection (58).

Sixty-six adult patients having a craniotomy for brain tumour resection were randomised to maintenance of anaesthesia with either propofol-remifentanil (n=31) or sevoflurane-sufentanil (n=35) to compare the emergence characteristics between these two techniques (59). Intravenous or volatile anaesthetic doses were both guided by bispectral index monitoring. Opioid administration was titrated to heart rate and mean arterial pressure values. Post-operatively, patients in the sevoflurane-sufentanil group achieved maximum scores on consciousness targets, namely, GCS, Aldrete score, and Mini-Mental Status Examination score, more rapidly compared to patients in the propofol-remifentanil group. However, between the two patient groups, there were no significant time differences between the end of anaesthesia and the ability to breathe spontaneously, follow simple commands, and be successfully extubated (59). Other studies, designed to optimise rapid emergence for neurological assessment, have failed to show a distinct benefit of TIVA compared with a volatile-based anaesthetic technique (55, 60, 61).

In an early prospective randomised trial (62), further clinical differences between patients receiving a propofol-fentanyl or isoflurane-nitrous oxide anaesthetic were assessed. No significant haemodynamic differences were found between the two groups. Additionally, no clinically important differences in the measured mean ICP were found. However, more patients in the volatile-based anaesthesia group had ICP measurements that exceeded 24 mmHg, compared to the TIVA group. Magni et al. (63) found that elective craniotomy patients receiving propofol experienced significantly more haemodynamic changes but no clinically significant differences in surgically assessed brain swelling. A similar study in emergency craniotomy patients showed no significant differences between propofol or sevoflurane groups for both episodes of hypotension and cerebral oedema (45). Of note, neither study measured ICP objectively.

Comparative studies on the ICP effects of anaesthetics show that all volatiles in a dose-dependent manner can increase ICP, but this effect is least for sevoflurane (57). On the contrary, propofol can reduce ICP (57), and some evidence exists that it may serve as a neuroprotectant (64). The importance of reducing ICP in TBI patients is reflected in the Brain Trauma Foundation guidelines (51). Furthermore, an association between the use of ICP monitoring in severe TBI patients, and a significantly reduced intensive care mortality, has been demonstrated (65). However, the findings of a prospective randomised controlled trial failed to show a significant outcome difference between severe TBI patients requiring emergency surgery receiving either a TIVA-based or volatile-based anaesthetic (45). This is in contrast to the findings of an earlier retrospective study which showed that TIVA was superior to volatile-based anaesthesia for TBI patients, although this benefit was greatest for the mild and moderate TBI groups (66).

Both TIVA and volatile-based anaesthesia are widely accepted for the anaesthetic management of supratentorial intracranial surgery (60, 61, 67, 68). The concern regarding the influence of anaesthetic technique on outcomes in brain tumour patients, specifically, stems from studies conducted in other cancer surgery patients, favouring the use of TIVA (69-71). A retrospective study (43) conducted at University Hospital Heidelberg, Germany, showed that the anaesthetic technique employed during the resection of glioblastoma did not impact patient survival. According to the authors, the chosen anaesthetic technique was based on the attending anaesthetist’s preference, and the retrospective study design prevented deductions relating to the rationale for the given choice to be made. In the majority of patients (88.5%), the anaesthetist elected a volatile-based approach. Of all the TIVA cases, in 16 (30.8%) patients, TIVA was mandated by the use of intra-operative electrophysiological monitoring (43). In view of the available literature, judicious use of either anaesthetic technique is appropriate in neurosurgical patients.

Airway and ventilatory management of neurosurgical patients

General anaesthesia, regardless of whether TIVA or volatile-based, raises unique airway management concerns in neurosurgical patients. Patients with cervical spine instability, Cushingoid features, and acromegalic patients should be anticipated difficult airways and contingency airway management plans should be in place (72). Certain procedures require head fixation devices to be placed following the induction of anaesthesia. Stereotactic headframes pose a major limitation if there is a need for urgent or emergency airway management (73). Simulation studies have shown that the time to intubate or rescue the airway with a laryngeal mask airway is longer once head fixation devices are in place compared to standard airway management conditions (74). The advent of awake craniotomies has heralded a variety of airway management strategies. These include the use of nasal cannulae (75), simple facemasks (76), laryngeal mask airways (77, 78), endotracheal tubes (77, 78), and the novel application of bilateral nasopharyngeal airways (76).

Most commonly, general anaesthesia will necessitate intubation and ventilation. Compared with the general surgical population, patients who undergo craniotomy procedures are at increased risk for post-operative respiratory complications (26, 45, 56, 67). A theoretical concern exists that adopting the lung-protective paradigm of application of high positive end-expired pressure would increase ICP and thus adversely affect cerebral perfusion (56). The effect of incremental positive end-expired pressure was studied in a randomised group of 40 adult patients undergoing brain tumour resection (79). No statistically significant differences in ICP measurements were noted between the standard and the lung-protective ventilated groups. No outcome benefit was demonstrated in a similar study in patients having spine surgery in the prone position (80).

Analgesic management of neurosurgical patients

Opioids are often the mainstay of analgesic management in neurosurgical patients (9, 56, 73, 81, 82). Uchida et al. (83) found that in patients undergoing brain tumour resection, the intraoperative use of remifentanil, when compared to the use of fentanyl, was associated with reduced in-hospital mortality. The same authors applied this observation to patients who underwent cerebral aneurysm clipping (84). Similarly, patients who received remifentanil experienced significantly lower mortality rates (4.2%) compared to those who received fentanyl alone (7.7%; $P<0.001$). The purported theory for these findings relates to remifentanil possibly suppressing the stress response to surgery, and therefore mitigating consequent hyperglycaemia and inflammation, more so than fentanyl (84).

The analgesic management of neurosurgical patients is further challenged in needing to balance adequate analgesia, while mitigating the concurrent sedating effects of opioids to allow for accurate post-operative neurological assessment. As such, various opioid-sparing techniques have emerged using drugs such as dexmedetomidine (85), paracetamol (86, 87), and ketamine (88, 89) in cranial and spinal surgery patients. Scalp infiltration with local anaesthetic decreases post-operative pain scores and morphine consumption, but only for the first two hours after cranial surgery (90). Of novel interest, while the use of ketamine in TBI patients was previously discouraged, it may be unjustified in light of new information supporting ketamine as a potential neuroprotectant agent (89, 91).

This may in part explain the findings of Grathwohl et al. (66), demonstrating superiority in a TIVA-based anaesthetic technique since TBI patients receiving ketamine-based anaesthesia were included in the final outcome analysis.

Haemodynamic management of neurosurgical patients

The principal risk of intra-operative hypotension is end-organ ischaemia due to reduced organ perfusing pressure (92, 93). The practice of permissive hypotension (PH) is largely advocated by surgeons with a view to optimise operative fields and minimise intra-operative blood loss (94-96). Soghomonyan et al. (96) sought to establish the practise patterns surrounding PH in contemporary neuroanaesthetic practice. In their survey, they found that 87.5% of respondents reported using PH for selective neurosurgical procedures. Of these respondents, 73.1% denied awareness of patient complications due to PH strategies. The survey showed large inter-practise variability in terms of selected target values, whether systolic or mean arterial blood pressure measurements guided technique, type of vasoactive substances utilised, and the level of haemodynamic monitoring employed. The authors concluded that the role of PH in modern neuroanaesthesia needs further studies to clarify safety and best practice guidelines (96).

On the contrary, induced hypertension may have a protective role in select neurosurgical patients (97). Delayed cerebral ischaemia contributes to downstream morbidity and mortality in aneurysmal SAH survivors (98). There is a dichotomy in professional opinion regarding the best therapeutic approach in these patients (97). Haegens et al. (97) retrospectively investigated the role of induced hypertension in patients with symptomatic delayed cerebral ischaemia. They found a significantly reduced incidence of subsequent cerebral infarction in patients treated with induced hypertension. Additionally, significantly fewer patients treated with induced hypertension had a modified Rankin score >3, indicating a lower rate of poorer outcomes among these patients, compared with patients who were not treated with induced hypertension. In patients that were treated with induced hypertension, noradrenaline was the vasopressor of choice (97). In South African, noradrenaline use is subject to Section 21 authorisation for access to unregistered medication (99), and thus widespread availability is limited.

Phenylephrine and ephedrine are readily available vasopressors and are commonly administered to neurosurgical patients to manage intra-operative hypotension (100). However, phenylephrine may not be the ideal agent since several studies in non-neurosurgical patients suggest a reduction in cerebral oxygen saturation with its use, compared to ephedrine (101-103). It would be expected that this observed perturbation associated with phenylephrine use may be even more pronounced in patients with intracranial pathology. Koch et al. (104) studied the cerebral physiological effects of vasopressor administration in brain tumour patients in a double-blinded randomised clinical trial. The study showed that there were no significant differences in oxygen metabolic rate of peri-tumour and normal contralateral areas between the two vasopressors. However, in keeping with earlier studies (101-103), assessment of the normal hemisphere showed that ephedrine administration resulted in increased cerebral oxygenation compared to phenylephrine (104).

Blood transfusion practices in neurosurgical patients

Both cranial and spinal surgery have the potential for blood loss mandating the transfusion of red packed cells (105, 106). Physiological assessments guided by neurophysiological monitoring devices have shown improved cerebral oxygenation in neurosurgical patients following blood transfusion (107). However, these improvements in oxygen delivery have not consistently translated into clinical benefit. Moreover, ideal transfusion triggers in neurosurgical patients remain undefined (108) and may also differ depending on the underlying neuropathology (109). In patients with severe TBI, maintaining haemoglobin levels >9g/dL may have an association with improved neurological outcome (110, 111). Antagonistically, liberal transfusion practices have been associated with increased mortality rates. A retrospective study among severe TBI patients showed an in-hospital mortality of 41.0% in patients receiving a transfusion compared to 24.0% in those not transfused ($p<0.05$) (112). The study also showed that in their population transfusion was independently associated with increased risk for neurological complications [RR=3.4 (±95% CI 1.4, 8.6) $P<0.05$], as well as longer ICU, and hospital lengths of stay (112).

In other neurosurgical patients, the role of blood transfusion is equally contentious. Bell et al. (113) described intra-arterial vasospasm therapy practices in aneurysmal SAH patients and showed that a lower mean haemoglobin level was predictive of both the need for therapy and poor neurological outcome post-intervention. Antagonistically, the transfusion of red packed cells in aneurysmal SAH patients may be associated with an increased incidence of vasospasm (114), cerebral aneurysm rupture (115), and increased in-hospital mortality (116). On the contrary, English et al. (117) found that red packed cell transfusion did not correlate with mortality in their SAH cohort but restrictive transfusion practices were noted among the studied institutions. Brain tumour resection poses a risk for blood loss and the need for transfusion due to the vascular nature of certain tumours and the development of disseminated intravascular coagulopathy (109). In patients with tumours, the immunomodulatory effects of blood transfusion may cause cancer progression (118), further complicating risk-benefit analyses for intracranial and spinal tumour patients. Emphasis on individualised blood conservation strategies (108) may ameliorate the frequency of required blood transfusions in neurosurgical patients.

Adjuvant peri-operative medical management of neurosurgical patients

Steroids and anti-convulsant agents are commonly administered medications in neurosurgical patients (82). Steroids have an important role in managing cerebral oedema associated with brain tumours (119). The Brain Trauma Foundation states that steroid administration to TBI patients is harmful and is not recommended (51). Generalised seizures can cause marked derangements in cerebral blood flow, cerebral metabolic rate, and ICP (120). These extreme physiologic changes associated with seizure activity may have detrimental patient effects if not managed appropriately. The latter is evidenced by the risk of death produced by electroconvulsive therapy in patients harbouring unknown brain tumours (121). However, peri-operative administration of anti-convulsant medication is not routine in all neurosurgical patients. A systematic review showed a limited clinical benefit of prophylactic anti-convulsant administration in the prevention of post-craniotomy seizures (122). The Brain Trauma Foundation (51) recommends phenytoin to decrease the incidence of early-onset post-traumatic seizures in light of level IIA evidence.

Hypertonic solutions are agents composed of a solute that cannot cross the blood-brain barrier and act to treat elevated ICP (73). Mannitol or sodium chloride are the commonly administered hypertonic solutions to treat intracranial hypertension. There is an ongoing debate as to which is the superior agent (123-125). In a study by Ali et al. (125), various clinical, physiological, and biochemical effects of mannitol and hypertonic saline were analysed. The study participants included 39 elective cranial surgery patients with brain tumours who had computed tomography evidence of raised ICP.

Baseline ICP measurements, which were similar between the two patient groups, were made via stereotactically placed probes at the tumour site following a burr hole and preceding hypertonic solution administration. Once standardised doses of respective hypertonic solutions were given, ICP was measured for 45 minutes, after which time the craniotomy was performed (125). Patients receiving hypertonic saline showed a significantly greater reduction in absolute and relative ICP when compared with ICP measurements in the mannitol patient group. Further differences between the two patient groups included a significant decrease in pulse pressure variation with hypertonic saline administration and a significant increase in serum lactate concentration with mannitol use (125).

1.5 The post-operative characteristics of neurosurgical patients

Institutional resources and scope of practice dictate the post-operative management plan for individual patients. Several case series in the literature describe ambulatory neurosurgical practices (126). Many patients are sent to the ward following their surgery (127). The type of neurosurgical procedure, along with certain patient characteristics and comorbidities, increases the risk of post-operative complications. This subset of patients may benefit from post-operative intensive care (127, 128). In addition to complication rates (26, 45, 67), other post-operative events are identified in neurosurgical patient populations to serve as crude indices of the quality of health care delivered. Commonly studied metrics include, re-operation rates (129, 130), re-admission rates (131-133), length of hospital stay (134, 135), and mortality (7, 26, 33, 36, 43, 45). Mortality rate is a common outcome metric for its discriminatory nature (dead or alive), and routine incorporation into administrative databases.

The thirty-day complication rate in the Rock et al. (26) cohort was significantly higher in patients having cranial (22.0%) compared with spinal surgery (11.0%; $p<0.001$). The three most common complications in the cranial surgery group were the need for reoperation (6.8%), the need for blood transfusion (5.6%), and pneumonia (3.2%). The three strongest predictors for complications were ASA class V, pre-operative ventilator dependence, and pre-operative need for blood transfusion. Thirty-day mortality rates were significantly higher in the cranial (4.8%) compared with the spinal surgery group (0.5%; $p<0.001$). ASA class V, IV, and III were the three strongest predictors of mortality (26).

A retrospective survey of 583 TBI patients admitted to the National University Hospital of Iceland was done over 15 years (33). Craniotomies were performed most frequently in patients with moderate TBI (30.6%), whereas 26.4% and 24.3% of craniotomies were done for patients with severe and mild TBI, respectively. The mortality rate was significantly higher in the severe TBI group at 36.8%, compared to the mortality among moderate (9.0%) and mild (3.0%) TBI patients ($p<0.0001$). In the Austrian Severe Traumatic Brain Injury Study (31), severe TBI accounted for 13.0% of all TBI patients in this series and intensive care unit mortality was found to be 31.6% for severe TBI patients. A study from Lebanon reported specific mortality rates of 26.6% and 13.7% owing to infectious and non-infectious causes of post-TBI mortality, respectively (32).

Mulango National Referral Hospital in Uganda conducted a retrospective review of 120 severe TBI patients managed at the institution (32). An in-hospital mortality rate of 25.8% was observed. Mortality was greatest in the >45 age group at 40.0%. Patient age, gender, transfer time delays, length of hospital stay, pupillary reactivity, and the administration of mannitol were not significantly associated with outcome (32). A survey of 3 301 mixed adult and paediatric patient records extracted from the electronic systems of two hospitals in Pietermaritzburg found that there was a statistically significant difference in the mean GCS of TBI survivors of 13.7 compared to a mean GCS score of 5.7 among patients who demised ($p<0.001$). The authors reported an overall mortality rate for severe TBI patients in the studied population at 33.4% (7).

The validity of available outcome quality indicators has been questioned (4). A study in Sri Lanka sought to assess the long-term neurological status of patients admitted with moderate and severe TBI to a tertiary neurocritical care unit (36). A telephonically administered questionnaire based on the Glasgow Outcome Scale Extended score was used to assess the functional outcome of patients at three and six months after injury. At three months following injury, only 38.0% of survivors were found to have good functional recovery. Such enquiries serve to better elucidate the impact of various management strategies on patient outcomes.

1.6 Summary

The provision of high-quality health care to neurosurgical patients is an ingrained tenet among all health care providers involved in their management. Databases are being ear-marked as instrumental tools to measure the quality of care delivered. This literature review has addressed aspects of the Charlotte Maxeke Johannesburg Academic Hospital REDCap neuroanaesthesia database. Neurosurgical patient demographics for several neurosurgical conditions have been described. The controversies surrounding the use of GCS in the pre-operative neurological assessment of TBI patients have been highlighted. Standard of neurosurgical care and neuroanaesthetic controversies in the intra-operative management of neurosurgical patients has been addressed. Particular emphasis has been placed on the anaesthetic technique, airway, ventilatory, analgesic, haemodynamic, blood transfusion, and peri-operative adjuvant medical management of neurosurgical patients by anaesthesiologists. Finally, a description of the post-operative characteristics of neurosurgical patients has been provided. Post-operative events are the metrics employed to benchmark the overall quality of the antecedent care provided.

1.7 References

1. Institute of Medicine, Committee on the Quality of Health Care in America. Crossing the quality chasm: A new health system for the 21st Century. National Academy Press; 2001. [Accessed: 26 August 2017] Available at: http://www.nap.edu/catalog/10027.html.

2. Barker FG II. Pursuing excellence in healthcare delivery: American neurosurgery. Clin Neurosurg. 2010;57:60-8.

3. Lau CY. Quality improvement tools and processes. Neurosurg Clin N Am. 2015;26(2):177-87. doi:10.1016/j.nec.2014.11.016

4. Schipmann S, Schwake M, Suero Molina E, Roeder N, Steudel WI, Warneke N, et al. Quality indicators in cranial neurosurgery: Which are presently substantiated? - A systematic review. World Neurosurg. 2017;104:104-12. doi:10.1016/j.wneu.2017.03.111

5. Bradshaw D, Nannan N, Laubscher R, Groenewald P, Joubert J, Nojilana B, et al. South African National Burden of Disease Study 2000. Estimates of provincial mortality: Summary report. Medical Research Council; 2006. [Accessed: 12 September 2017] Available at: https://www.samrc.ac.za/sites/default/files/files/2017-07-03/estimate.pdf.

6. Nell V, Brown DSO. Epidemiology of traumatic brain injury in Johannesburg—II. Morbidity, mortality and etiology. Soc Sci Med. 1991;33(3):289-96. doi:10.1016/0277-9536(91)90363-H

7. Jerome E, Laing GL, Bruce JL, Sartorius B, Brysiewicz P, Clarke DL. An audit of traumatic brain injury (TBI) in a busy developing-world trauma service exposes a significant deficit in resources available to manage severe TBI. S Afr Med J. 2017;107:621-5. doi:10.7196/SAMJ.2017.v107i7.10562

8. Schrieff LE, Thomas KGF, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 2006 - 2011 : Research. S Afr Med J. 2013;103(9):616-20. doi:10.7196/SAMJ.7137

9. Allopi K, Padayachee L. An audit of the perioperative anaesthetic management of ventriculoperitoneal shunt insertion in the paediatric population at Inkosi Albert Luthuli Central Hospital. S Afr J Anaesth Analg. 2014;20(5):209-13. doi:10.1080/22201181.2014.979635

10. National Planning Commission. National Development Plan 2030. Our future: make it work. Pretoria: 2012 [Accessed 25 August 2017]. Available at: http://www..poa.gov.za/news/Documents/NPC%20National%20Development%20Plan%20Vision%202030%20-lo-res.pdf.
11. National Department of Health, Republic of South Africa. National Health Insurance for South Africa: Towards universal health coverage. Pretoria: 2017 [Accessed 29 November 2017]. Available at: www.health.gov.za/index.php/nhi?download=2257:white-paper-nhi-2017.
12. Naidoo D. Traumatic brain injury: The South African landscape. S Afr Med J. 2013;103(9). doi:10.7196/SAMJ.7325
13. Asher AL, Parker SL, Rolston JD, Selden NR, McGirt MJ. Using clinical registries to improve the quality of neurosurgical care. Neurosurg Clin N Am. 2015;26(2):253-63. doi:10.1016/j.nec.2014.11.010
14. Bradford NK. Interventions to increase the use of electronic health information by healthcare practitioners to improve clinical practice and patient outcomes. Int J EBH. 2016;14(3):136-7. doi:10.1097/xeb.0000000000000074
15. Vener DF, Pasquali SK, Mossad EB. Anesthesia and databases: Pediatric cardiac disease as a role model. Anesth Analg 2017;124(2):572-81. doi:10.1213/ane.0000000000001448
16. Nguyen R, Fiest KM, McChesney J, Kwon C-S, Jette N, Frolkis AD, et al. The international incidence of traumatic brain injury: A systematic review and meta-analysis. Can J Neuro Sci. 2016;43(6):774-85. doi:10.1017/cjn.2016.290
17. Rincon F, Rossennasser RH, Dumont A. The epidemiology of admissions of nontraumatic subarachnoid hemorrhage in the United States. Neurosurg. 2013;73:217-23. doi:10.1227/01.neu.0000430290.93304.33
18. Adigun TA, Akinyemi OA, Amanorboadu SD, Adeleye AO, Shokunbi MT. An audit of anaesthesia for paediatric neurosurgical procedures in Ibadan, Nigeria. African Journal of Anaesthsia and Intensive Care. 2014;14(1):12-6.
19. Barnholtz-Sloan JS, Ostrom QT, Cote D. Epidemiology of brain tumors. Neurol Clin. 2018;36(3):395-419. doi:10.1016/j.ncl.2018.04.001
20. Dewan MC, Rattani A, Gupta S, Baticulon RE, Hung YC, Punchak M, et al. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018:1-18. doi:10.3171/2017.10.Jns17352

21. Dewan MC, Rattani A, Mekary R, Glancz LJ, Yunusa I, Baticulon RE, et al. Global hydrocephalus epidemiology and incidence: Systematic review and meta-analysis. J Neurosurg. 2018:1-15. doi:10.3171/2017.10.Jns17439
22. Robertson FC, Lepard JR, Mekary RA, Davis MC, Yunusa I, Gormley WB, et al. Epidemiology of central nervous system infectious diseases: A meta-analysis and systematic review with implications for neurosurgeons worldwide. J Neurosurg. 2018:1-20. doi:10.3171/2017.10.Jns17359
23. Vaughan KA, Lopez Ramos C, Buch VP, Mekary RA, Amundson JR, Shah M, et al. An estimation of global volume of surgically treatable epilepsy based on a systematic review and meta-analysis of epilepsy. J Neurosurg. 2018:1-15. doi:10.3171/2018.3.Jns171722
24. Beghi E. The epidemiology of epilepsy. Neuroepidemiology. 2020;54(2):185-91. doi:10.1159/000503831
25. Dewan MC, Rattani A, Fieggen G, Arraez MA, Servadei F, Boop FA, et al. Global neurosurgery: The current capacity and deficit in the provision of essential neurosurgical care. Executive Summary of the Global Neurosurgery Initiative at the Program in Global Surgery and Social Change. J Neurosurg. 2018:1-10. doi:10.3171/2017.11.Jns171500
26. Rock AK, Opalak CF, Workman KG, Broaddus WC. Safety outcomes following spine and cranial neurosurgery: Evidence from the National Surgical Quality Improvement Program. J Neurosurg Anesthesiol. 2018;30(4):328-36. doi:10.1097/ana.0000000000000474
27. Emejulu JKC, Osuafor C, CN. O. Audit of the demographic patterns of neurosurgical cases in a tertiary health institution: The need to relate service delivery to disease profile in dwindling resources and manpower shortage. African Journal of Neurological Sciences. 2009;28(2):15-21.
28. Abou-Abbass H, Bahmad H, Ghandour H, Fares J, Wazzi-Mkahal R, Yacoub B, et al. Epidemiology and clinical characteristics of traumatic brain injury in Lebanon: A systematic review. Medicine. 2016;95(47):e5342. doi:10.1097/MD.0000000000005342
29. Georgoff P, Meghan S, Mirza K, Stein SC. Geographic variation in outcomes from severe traumatic brain injury. World Neurosurg. 2010;74(2–3):331-45. doi:10.1016/j.wneu.2010.03.025

30. Gerber LM, Chiu Y-L, Carney N, Härtl R, Ghajar J. Marked reduction in mortality in patients with severe traumatic brain injury. J Neurosurg. 2013;119(6):1583. doi:10.3171/2013.8.Jns13276

31. Rosso A, Brazinova A, Janciak I, Wilbacher I, Rusnak M, Mauritz W. Severe traumatic brain injury in Austria II: Epidemiology of hospital admissions. Wien Klin Wochenschr. 2007;119(1-2):29-34. doi:10.1007/s00508-006-0761-4

32. Tran TM, Fuller AT, Kiryabwire J, Mukasa J, Muhumuza M, Ssenyojo H, et al. Distribution and characteristics of severe traumatic brain injury at Mulago National Referral Hospital in Uganda. World Neurosurg. 2015;83(3):269-77. doi:10.1016/j.wneu.2014.12.028

33. Jonsdottir GM, Lund SH, Snorradottir B, Karason S, Olafsson IH, Reynisson K, et al. A population-based study on epidemiology of intensive care unit treated traumatic brain injury in Iceland. Acta Anaesthesiol Scand. 2017;61(4):408-17. doi:10.1111/aas.12869

34. Cnossen MC, Polinder S, Vos PE, Lingsma HF, Steyerberg EW, Sun Y, et al. Comparing health-related quality of life of Dutch and Chinese patients with traumatic brain injury: do cultural differences play a role? Health Qual Life Outcomes. 2017;15:72-88. doi:10.1186/s12955-017-0641-9

35. Boniface R, Lugazia ER, Ntungi AM, Kiloloma O. Management and outcome of traumatic brain injury patients at Muhimbili Orthopaedic Institute Dar es Salaam, Tanzania. Pan Afr Med J. 2017;26:140-6. doi:doi:10.11604/pamj.2017.26.140.10345

36. Samanamalee S, Sigera PC, De Silva AP, Thilakasiri K, Rashan A, Wadanambi S, et al. Traumatic brain injury (TBI) outcomes in an LMIC tertiary care centre and performance of trauma scores. BMC Anesthesiol. 2018;18(1):4-11. doi:10.1186/s12871-017-0463-7

37. Heth JA. Neurosurgical aspects of central nervous system infections. Neuroimaging Clin N Am. 2012;22(4):791-9. doi:10.1016/j.nic.2012.05.005

38. Anwary MA. Intracranial suppuration: Review of an 8-year experience at Umtata General Hospital and Nelson Mandela Academic Hospital, Eastern Cape, South Africa. S Afr Med J. 2015;150(7):584-8. doi:10.7196/SAMJnew.7882

39. Human Sciences Research Council (2018) The Fifth South African National HIV Prevalence, Incidence, Behaviour and Communication Survey, 2017.

[Accessed 28 January 2021] Available at: https://www.aidshealth.org/wp-content/uploads/2018/08/hsrc-survey-2018-summary.pdf.
40. Kim T, Lee H, Ahn S, Kwon O-K, Bang JS, Hwang G, et al. Incidence and risk factors of intracranial aneurysm: A national cohort study in Korea. Int J Stroke. 2016;11(8):917-27. doi:10.1177/1747493016660096
41. Swartbooi A, Meyer C, de Vries C. Digital subtraction angiography findings and population demographics of patients with subarachnoidal haemorrhage and subsequent causative aneurysms at Universitas Academic Hospital, Bloemfontein. SA J Radiol. 2016;20(1). doi:10.4102/sajr.v20i1.1030
42. Ostrom QT, Gittleman H, Liao P, Vecchione-Koval T, Wolinsky Y, Kruchko C, et al. CBTRUS Statistical Report: Primary brain and other central nervous system tumors diagnosed in the United States in 2010-2014. Neuro Oncol. 2017;19(5):1-88. doi:10.1093/neuonc/nox158
43. Schmoch T, Jungk C, Bruckner T, Haag S, Zweckberger K, von Deimling A, et al. The anesthetist's choice of inhalational vs. intravenous anesthetics has no impact on survival of glioblastoma patients. Neurosurg Rev [E-publication]. 2020. doi:10.1007/s10143-020-01452-7
44. Somani S, Capua JD, Kim JS, Phan K, Lee NJ, Kothari P, et al. ASA classification as a risk stratification tool in adult spinal deformity surgery: A study of 5805 patients. Global Spine J. 2017;7(8):719-26. doi:10.1177/2192568217700106
45. Wan Hassan WMN, Mohd Nasir Y, Mohamad Zaini RH, Wan Muhd Shukeri WF. Target-controlled infusion propofol versus sevoflurane anaesthesia for emergency traumatic brain surgery: Comparison of the outcomes. Malays J Med Sci. 2017;24(5):73-82. doi:10.21315/mjms2017.24.5.8
46. Ringdal K, Skaga N, Steen P, Hestnes M, Laake P, Jones J, et al. Classification of comorbidity in trauma: The reliability of pre-injury ASA physical status classification. Injury. 2012;44. doi:10.1016/j.injury.2011.12.024
47. Singram S, Naidu S. Use of The American Society of Anaesthesiologists Physical Status Classification in non-trauma surgical versus trauma patients: A survey of inter-observer consistency. S Afr J Anaesth Analg. 2018;24(3):14-8.
48. Himmelseher S, Pfenninger E. Anaesthetic management of neurosurgical patients. Curr Opin Anaesthesiol. 2001;14:483-90. doi:10.1097/00001503-200110000-0004.

49. Reith FC, Brennan PM, Maas AI, Teasdale GM. Lack of standardization in the use of the Glasgow coma scale: Results of international surveys. J Neurotrauma. 2016;33(1):89-94. doi:10.1089/neu.2014.3843

50. Saatman KE, Duhaime AC, Bullock R, Maas AI, Valadka A, Manley GT. Classification of traumatic brain injury for targeted therapies. J Neurotrauma. 2008;25(7):719-38. doi:10.1089/neu.2008.0586

51. Carney N, Totten AM, O'Reilly C, Ullman JS, Hawryluk JWG, Bell MJ, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. Neurosurgery. 2017;80(1):6-15. doi:10.1227/neu.0000000000001432

52. Majdan M, Brazinova A, Rusnak M, Leitgeb J. Outcome prediction after traumatic brain injury: Comparison of the performance of routinely used severity scores and multivariable prognostic models. J Neurosci Rural Pract. 2017;8(1):20-9. doi:10.4103/0976-3147.193543

53. Tenovuo O, Diaz-Arrastia R, Goldstein LE, Sharp DJ, van der Naalt J, Zasler ND. Assessing the severity of traumatic brain injury-Time for a change? J Clin Med. 2021;10(1):1-12. doi:10.3390/jcm10010148

54. Majdan M, Steyerberg EW, Nieboer D, Mauritz W, Rusnak M, Lingsma HF. Glasgow coma scale motor score and pupillary reaction to predict six-month mortality in patients with traumatic brain injury: Comparison of field and admission assessment. J Neurotrauma. 2015;32(2):101-8. doi:10.1089/neu.2014.3438

55. Chui J, Mariappan R, Mehta J, Manninen P, Venkatraghavan L. Comparison of propofol and volatile agents for maintenance of anesthesia during elective craniotomy procedures: Systematic review and meta-analysis. Can J Anaesth. 2014;61(4):347-56. doi:10.1007/s12630-014-0118-9

56. Pasternak JJ, Lanier WL. Neuroanesthesiology update. J Neurosurg Anesthesiol. 2015;27(2):87-122. doi:10.1097/ana.0000000000000167

57. Cole C, Gottfried O, Gupta D, Couldwell W. Total intravenous anesthesia: Advantages for intracranial surgery. Neurosurg. 2007;61:369-77. doi:10.1227/01.neu.0000303996.74526.30

58. Kim R. Effects of surgery and anesthetic choice on immunosuppression and cancer recurrence. J Transl Med. 2018;16(1):8-21. doi: 10.1186/s12967-018-1389-7

59. Necib S, Tubach F, Peuch C, LeBihan E, Samain E, Mantz J, et al. Recovery from anesthesia after craniotomy for supratentorial tumors: Comparison

of propofol-remifentanil and sevoflurane-sufentanil (the PROMIFLUNIL trial). J Neurosurg Anesthesiol. 2014;26(1):37-44. doi:10.1097/ANA.0b013e31829cc2d6
60. Lauta E, Abbinante C, Del Gaudio A, Aloj F, Fanelli M, de Vivo P, et al. Emergence times are similar with sevoflurane and total intravenous anesthesia: Results of a multicenter RCT of patients scheduled for elective supratentorial craniotomy. J Neurosurg Anesthesiol. 2010;22(2):110-8. doi:10.1097/ANA.0b013e3181c959da
61. Prabhakar H, Singh GP, Mahajan C, Kapoor I, Kalaivani M, Anand V. Intravenous versus inhalational techniques for rapid emergence from anaesthesia in patients undergoing brain tumour surgery. The Cochrane database of systematic reviews. 2016;9(9):Cd010467. doi:10.1002/14651858.CD010467.pub2
62. Todd MM, Warner DS, Sokoll MD, Maktabi MA, Hindman BJ, Scamman FL, et al. A prospective, comparative trial of three anesthetics for elective supratentorial craniotomy. Propofol/fentanyl, isoflurane/nitrous oxide, and fentanyl/nitrous oxide. Anesthesiology. 1993;78(6):1005-20. doi:10.1097/00000542-199306000-00002
63. Magni G, Baisi F, La Rosa I, Imperiale C, Fabbrini V, Pennacchiotti ML, et al. No difference in emergence time and early cognitive function between sevoflurane-fentanyl and propofol-remifentanil in patients undergoing craniotomy for supratentorial intracranial surgery. J Neurosurg Anesthesiol. 2005;17(3):134-8. doi:10.1097/01.ana.0000167447.33969.16
64. Kawaguchi M, Furuya H, Patel PM. Neuroprotective effects of anesthetic agents. J Anesth. 2005;19(2):150-6. doi:10.1007/s00540-005-0305-5
65. Mauritz W, Janciak I, Wilbacher I, Rusnak M. Severe traumatic brain injury in Austria IV: Intensive care management. Wien Klin Wochenschr. 2007;119(1-2):46-55. doi:10.1007/s00508-006-0763-2
66. Grathwohl Kurt W, Black Ian H, Spinella Phillip C, Sweeney J, Robalino J, Helminiak J, et al. Total intravenous anesthesia including ketamine versus volatile gas anesthesia for combat-related operative traumatic brain injury. Anesthesiology. 2008;109(1):44-53. doi:10.1097/ALN.0b013e31817c02e3
67. Magni G, La Rosa I, Gimignani S, Melillo G, Imperiale C, Rosa G. Early postoperative complications after intracranial surgery: Comparison between total intravenous and balanced anesthesia. J Neurosurg Anesthesiol. 2007;19(4):229-34. doi:10.1097/ANA.0b013e31806e5f5a

68. Prabhakar H, Sharma M, Jain V, Ali Z, Bithal P, Dash H. Controversial issues in neuroanaesthesia and their current practice in India-A questionnaire survey. Indian J Anaesth. 2008;52(6):823-28.
69. Enlund M, Berglund A, Andreasson K, Cicek C, Enlund A, Bergkvist L. The choice of anaesthetic--sevoflurane or propofol--and outcome from cancer surgery: A retrospective analysis. Ups J Med Sci. 2014;119(3):251-61. doi:10.3109/03009734.2014.922649
70. Lee JH, Kang SH, Kim Y, Kim HA, Kim BS. Effects of propofol-based total intravenous anesthesia on recurrence and overall survival in patients after modified radical mastectomy: A retrospective study. Korean J Anesthesiol. 2016;69(2):126-32. doi:10.4097/kjae.2016.69.2.126
71. Wigmore TJ, Mohammed K, Jhanji S. Long-term survival for patients undergoing volatile versus IV anesthesia for cancer surgery: A retrospective analysis. Anesthesiology. 2016;124(1):69-79. doi:10.1097/aln.0000000000000936
72. Aziz M. Airway management in neuroanesthesiology. Anesthesiol Clin. 2012;30(2):229-40. doi:10.1016/j.anclin.2012.04.001
73. Pasternak JJ. Neuroanesthesiology Update. J Neurosurg Anesthesiol. 2019;31(2):178-98. doi:10.1097/ana.0000000000000581
74. Brockerville M, Unger Z, Rowland NC, Sammartino F, Manninen PH, Venkatraghavan L. Airway management with a stereotactic headframe in situ: A mannequin study. J Neurosurg Anesthesiol. 2018;30(1):44-8. doi:10.1097/ana.0000000000000402
75. Skucas AP, Artru AA. Anesthetic complications of awake craniotomies for epilepsy surgery. Anesth Analg. 2006;102(3):882-7. doi:10.1213/01.ane.0000196721.49780.85
76. Sivasankar C, Schlichter RA, Baranov D, Kofke WA. Awake craniotomy: A new airway approach. Anesth Analg. 2016;122(2):509-11. doi:10.1213/ane.0000000000001072
77. Zhang K, Gelb AW. Awake craniotomy: Indications, benefits, and techniques. Colombian Journal of Anesthesiology. 2018;46(2S):46-51. doi:10.1097/cj9.0000000000000045
78. Burnand C, Sebastian J. Anaesthesia for awake craniotomy. BJA Educ. 2013;14(1):6-11. doi:10.1093/bjaceaccp/mkt024

79. Ruggieri F, Beretta L, Corno L, Testa V, Martino EA, Gemma M. Feasibility of protective ventilation during elective supratentorial neurosurgery: A randomized, crossover, clinical trial. J Neurosurg Anesthesiol. 2018;30(3):246-50. doi:10.1097/ana.0000000000000442
80. Soh S, Shim JK, Ha Y, Kim YS, Lee H, Kwak YL. Ventilation with high or low tidal volume with PEEP does not influence lung function after spinal surgery in prone position: A randomized controlled trial. J Neurosurg Anesthesiol. 2018;30(3):237-45. doi:10.1097/ana.0000000000000428
81. Ravussin P, Wilder-Smith O. General anaesthesia for supratentorial neurosurgery. CNS drugs. 2001;15(7):527-35. doi:10.2165/00023210-200115070-00003
82. Ho S, Hambidge O, John R. Anaesthesia for neurosurgery. Anaesthesia & Intensive Care Medicine. 2020;21(1):33-8. doi:10.1016/j.mpaic.2019.10.023
83. Uchida K, Yasunaga H, Miyata H, Sumitani M, Horiguchi H, Matsuda S, et al. Impact of remifentanil use on early postoperative outcomes following brain tumor resection or rectal cancer surgery. J Anesth. 2012;26(5):711-20. doi:10.1007/s00540-012-1397-3
84. Uchida K, Yasunaga H, Sumitani M, Horiguchi H, Fushimi K, Yamada Y. Effects of remifentanil on in-hospital mortality and length of stay following clipping of intracranial aneurysm: a propensity score-matched analysis. J Neurosurg Anesthesiol. 2014;26(4):291-8. doi:10.1097/ana.0000000000000039
85. Liu Y, Liang F, Liu X, Shao X, Jiang N, Gan X. Dexmedetomidine reduces perioperative opioid consumption and postoperative pain intensity in neurosurgery: A meta-analysis. J Neurosurg Anesthesiol. 2018;30(2):146-55. doi:10.1097/ana.0000000000000403
86. Artime CA, Aijazi H, Zhang H, Syed T, Cai C, Gumbert SD, et al. Scheduled intravenous acetaminophen improves patient satisfaction with postcraniotomy pain management: A prospective, randomized, placebo-controlled, double-blind study. J Neurosurg Anesthesiol. 2018;30(3):231-6. doi:10.1097/ana.0000000000000461
87. Burbridge MA, Stone SA, Jaffe RA. Acetaminophen does not reduce postoperative opiate consumption in patients undergoing craniotomy for cerebral revascularization: A randomized control trial. Cureus. 2019;11(1):e3863. doi:10.7759/cureus.3863

88. Pendi A, Field R, Farhan SD, Eichler M, Bederman SS. Perioperative ketamine for analgesia in spine surgery: A meta-analysis of randomized controlled trials. Spine. 2018;43(5):299-307. doi:10.1097/brs.0000000000002318
89. Bell JD. In vogue: Ketamine for neuroprotection in acute neurologic injury. Anesth Analg. 2017;124(4):1237-43. doi:10.1213/ane.0000000000001856
90. Yang X, Ma J, Li K, Chen L, Dong R, Lu Y, et al. A comparison of effects of scalp nerve block and local anesthetic infiltration on inflammatory response, hemodynamic response, and postoperative pain in patients undergoing craniotomy for cerebral aneurysms: A randomized controlled trial. BMC Anesthesiol. 2019;19(1):91-102. doi:10.1186/s12871-019-0760-4
91. Zeiler FA, Teitelbaum J, West M, Gillman LM. The ketamine effect on ICP in traumatic brain injury. Neurocrit Care. 2014;21(1):163-73. doi:10.1007/s12028-013-9950-y
92. Sun LY, Wijeysundera DN, Tait GA, Beattie WS. Association of intraoperative hypotension with acute kidney injury after elective noncardiac surgery. Anesthesiology. 2015;123(3):515-23. doi:10.1097/aln.0000000000000765
93. Monk TG, Bronsert MR, Henderson WG, Mangione MP, Sum-Ping ST, Bentt DR, et al. Association between Intraoperative hypotension and hypertension and 30-day postoperative mortality in noncardiac surgery. Anesthesiology. 2015;123(2):307-19. doi:10.1097/aln.0000000000000756
94. Prasant MC, Kar S, Rastogi S, Hada P, Ali FM, Mudhol A. Comparative study of blood loss, quality of surgical field and duration of surgery in maxillofacial cases with and without hypotensive anesthesia. J Int Oral Health. 2014;6(6):18-21.
95. Hamilton H, Constantinou J, Ivancev K. The role of permissive hypotension in the management of ruptured abdominal aortic aneurysms. J Cardiovasc Surg. 2014;55(2):151-9.
96. Soghomonyan S, Stoicea N, Sandhu GS, Pasternak JJ, Bergese SD. The role of permissive and induced hypotension in current neuroanesthesia practice. Front Surg. 2017;4:1. doi:10.3389/fsurg.2017.00001
97. Haegens NM, Gathier CS, Horn J, Coert BA, Verbaan D, van den Bergh WM. Induced hypertension in preventing cerebral infarction in delayed cerebral ischemia after subarachnoid hemorrhage. Stroke. 2018;49(11):2630-6. doi:10.1161/strokeaha.118.022310

98. Brathwaite S, Macdonald RL. Current management of delayed cerebral ischemia: Update from results of recent clinical trials. Transl Stroke Res. 2014;5(2):207-26. doi:10.1007/s12975-013-0316-8

99. South African Health Products Authority (2020) Section 21: Orthodox Medicines for Human Use. [Accessed 16 March 2021] Available at: https://www.sahpra.org.za/unregistered-products/

100. Sookplung P, Siriussawakul A, Malakouti A, Sharma D, Wang J, Souter MJ, et al. Vasopressor use and effect on blood pressure after severe adult traumatic brain injury. Neurocrit Care. 2011;15(1):46-54. doi:10.1007/s12028-010-9448-9

101. Foss VT, Christensen R, Rokamp KZ, Nissen P, Secher NH, Nielsen HB. Effect of phenylephrine vs. ephedrine on frontal lobe oxygenation during caesarean section with spinal anesthesia: An open label randomized controlled trial. Front Physiol. 2014;5:81. doi:10.3389/fphys.2014.00081

102. Aliane J, Dualé C, Guesmi N, Baud C, Rosset E, Pereira B, et al. Compared effects on cerebral oxygenation of ephedrine vs phenylephrine to treat hypotension during carotid endarterectomy. Clin Exp Pharmacol Physiol. 2017;44(7):739-48. doi:10.1111/1440-1681.12759

103. Nissen P, Brassard P, Jørgensen TB, Secher NH. Phenylephrine but not ephedrine reduces frontal lobe oxygenation following anesthesia-induced hypotension. Neurocrit Care. 2010;12(1):17-23. doi:10.1007/s12028-009-9313-x

104. Koch KU, Mikkelsen IK, Aanerud J, Espelund US, Tietze A, Oettingen Gv, et al. Ephedrine versus phenylephrine effect on cerebral blood flow and oxygen consumption in anesthetized brain tumor patients: A randomized clinical trial. Anesthesiology. 2020;133(2):304-17. doi:10.1097/aln.0000000000003377

105. Sitohang D, Rachmawati AM, Mansyur A. Estimated blood loss in craniotomy. Nusantara Medical Science Journal. 2016;4:143-5.

106. Lei F, Li Z, He W, Tian X, Zheng L, Kang J, et al. Total and hidden blood loss between open posterior lumbar interbody fusion and transforaminal lumbar interbody fusion by Wiltse approach. Medicine. 2020;99(20):e19864. doi:10.1097/md.0000000000019864

107. Sekhon MS, McLean N, Henderson WR, Chittock DR, Griesdale DE. Association of hemoglobin concentration and mortality in critically ill patients with severe traumatic brain injury. Crit Care. 2012;16(4):R128. doi:10.1186/cc11431

108. Kisilevsky A, Gelb AW, Bustillo M, Flexman AM. Anaemia and red blood cell transfusion in intracranial neurosurgery: a comprehensive review. Br J Anaesth. 2018;120(5):988-98. doi:10.1016/j.bja.2017.11.108
109. Ali A, Hassan N, Syed S. Transfusion practices in neuranaesthesia. Indian J Anaesth. 2014;58(5):622-8. doi:10.4103/0019-5049.144670
110. Oddo M, Levine JM, Kumar M, Iglesias K, Frangos S, Maloney-Wilensky E, et al. Anemia and brain oxygen after severe traumatic brain injury. Intensive Care Medicine. 2012;38(9):1497-504. doi:10.1007/s00134-012-2593-1
111. Griesdale DE, Sekhon MS, Menon DK, Lavinio A, Donnelly J, Robba C, et al. Hemoglobin area and time index above 90 g/l are associated with improved 6-month functional outcomes in patients with severe traumatic brain injury. Neurocrit Care 2015;23(1):78-84. doi:10.1007/s12028-014-0096-3
112. Boutin A, Moore L, Green RS, Zarychanski R, Erdogan M, Lauzier F, et al. Hemoglobin thresholds and red blood cell transfusion in adult patients with moderate or severe traumatic brain injuries: A retrospective cohort study. J Crit Care. 2018;45:133-9. doi:10.1016/j.jcrc.2018.01.023
113. Bell DL, Kimberly WT, Yoo AJ, Leslie-Mazwi TM, Rabinov JD, Bell JE, et al. Low neurologic intensive care unit hemoglobin as a predictor for intra-arterial vasospasm therapy and poor discharge modified Rankin Scale in aneurysmal subarachnoid haemorrhage-induced cerebral vasospasm. J Neurointerv Surg. 2015;7(6):438-42. doi:10.1136/neurintsurg-2014-011164
114. Smith MJ, Le Roux PD, Elliott JP, Winn HR. Blood transfusion and increased risk for vasospasm and poor outcome after subarachnoid hemorrhage. J Neurosurg. 2004;101(1):1-7. doi:10.3171/jns.2004.101.1.0001
115. Luostarinen T, Lehto H, Skrifvars MB, Kivisaari R, Niemelä M, Hernesniemi J, et al. Transfusion frequency of red blood cells, fresh frozen plasma, and platelets during ruptured cerebral aneurysm surgery. World Neurosurg. 2015;84(2):446-50. doi:10.1016/j.wneu.2015.03.053
116. Festic E, Rabinstein AA, Freeman WD, Mauricio EA, Robinson MT, Mandrekar J, et al. Blood transfusion is an important predictor of hospital mortality among patients with aneurysmal subarachnoid hemorrhage. Neurocrit Care. 2013;18(2):209-15. doi:10.1007/s12028-012-9777-y
117. English SW, Chassé M, Turgeon AF, Lauzier F, Griesdale D, Garland A, et al. Anemia prevalence and incidence and red blood cell transfusion practices in

aneurysmal subarachnoid hemorrhage: results of a multicenter cohort study. Crit Care. 2018;22(1):169-81. doi:10.1186/s13054-018-2089-7
118. Atzil S, Arad M, Glasner A, Abiri N, Avraham R, Greenfeld K, et al. Blood transfusion promotes cancer progression: A critical role for aged erythrocytes. Anesthesiology. 2008;109(6):989-97. doi:10.1097/ALN.0b013e31818ddb72
119. Dietrich J, Rao K, Pastorino S, Kesari S. Corticosteroids in brain cancer patients: Benefits and pitfalls. Expert Rev Clin Pharmacol. 2011;4(2):233-42. doi:10.1586/ecp.11.1
120. Stafstrom CE, Carmant L. Seizures and epilepsy: An overview for neuroscientists. Cold Spring Harb Perspect Med. 2015;5(6). doi:10.1101/cshperspect.a022426
121. Buday J, Albrecht J, Mareš T, Podgorná G, Horáčková K, Kališová L, et al. Brain tumors and electroconvulsive therapy: A literature overview of the last 80 years. Front Neurol. 2020;11:723. doi:10.3389/fneur.2020.00723
122. Greenhalgh J, Weston J, Dundar Y, Nevitt SJ, Marson AG. Antiepileptic drugs as prophylaxis for postcraniotomy seizures. Cochrane Database Syst Rev 2020, Issue 4. Art. No.: CD007286. doi:10.1002/14651858.CD007286.pub5.
123. Li M, Chen T, Chen SD, Cai J, Hu YH. Comparison of equimolar doses of mannitol and hypertonic saline for the treatment of elevated intracranial pressure after traumatic brain injury: A systematic review and meta-analysis. Medicine. 2015;94(17):736-51. doi:10.1097/md.0000000000000736
124. Mangat HS, Chiu YL, Gerber LM, Alimi M, Ghajar J, Hartl R. Hypertonic saline reduces cumulative and daily intracranial pressure burdens after severe traumatic brain injury. J Neurosurg. 2015;122(1):202-10. doi:10.3171/2014.10.jns132545
125. Ali A, Tetik A, Sabanci PA, Altun D, Sivrikoz N, Abdullah T, et al. Comparison of 3% hypertonic saline and 20% mannitol for reducing intracranial pressure in patients undergoing supratentorial brain tumor surgery: A randomized, double-blind clinical trial. J Neurosurg Anesthesiol. 2018;30(2):171-8. doi:10.1097/ana.0000000000000446
126. Sheshadri V, Venkatraghavan L, Manninen P, Bernstein M. Anesthesia for same day discharge after craniotomy: Review of a single center experience. J Neurosurg Anesthesiol. 2018;30(4):299-304. doi:10.1097/ana.0000000000000483

127. de Almeida CC, Boone MD, Laviv Y, Kasper BS, Chen CC, Kasper EM. The utility of routine intensive care admission for patients undergoing intracranial neurosurgical procedures: A systematic review. Neurocrit Care. 2018;28(1):35-42. doi:10.1007/s12028-017-0433-4
128. Cinotti R, Bruder N, Srairi M, Paugam-Burtz C, Beloeil H, Pottecher J, et al. Prediction score for postoperative neurologic complications after brain tumor craniotomy: A multicenter observational study. Anesthesiology. 2018;129(6):1111-20. doi:10.1097/aln.0000000000002426
129. McLaughlin N, Jin P, Martin NA. Assessing early unplanned reoperations in neurosurgery: Opportunities for quality improvement. J Neurosurg. 2015;123(1):198-205. doi:10.3171/2014.9.JNS14666
130. Lin Y, Meguid RA, Hosokawa PW, Henderson WG, Hammermeister KE, Schulick RD, et al. An institutional analysis of unplanned return to the operating room to identify areas for quality improvement. Am J Surg. 2017;214(1):1-6. doi:10.1016/j.amjsurg.2016.10.021
131. Buchanan CC, Hernandez EA, Anderson JM, Dye JA, Leung M, Buxey F, et al. Analysis of 30-day readmissions among neurosurgical patients: Surgical complication avoidance as key to quality improvement. J Neurosurg. 2014;121(1):170-5. doi:10.3171/2014.4.JNS13944
132. Logan P. Marcus, Brandon A. McCutcheon, Abraham Noorbakhsh, Ralitza P. Parina, David D. Gonda, Clark Chen, et al. Incidence and predictors of 30-day readmission for patients discharged home after craniotomy for malignant supratentorial tumors in California (1995–2010). J Neurosurg. 2014;120(5):1201-11. doi:10.3171/2014.1.jns131264
133. Bina RW, Lemole GM, Dumont TM. Measuring quality of neurosurgical care: Readmission is affected by patient factors. World Neurosurg.88:21-4. doi:10.1016/j.wneu.2015.12.091
134. Collins TC, Daley J, Henderson WH, Khuri SF. Risk factors for prolonged length of stay after major elective surgery. Ann Surg. 1999;230(2):251-57.
135. Dasenbrock HH, Liu KX, Devine CA, Chavakula V, Smith TR, Gormley WB, et al. Length of hospital stay after craniotomy for tumor: a National Surgical Quality Improvement Program analysis. Neurosurg Focus. 2015;39(6):E12. doi:10.3171/2015.10.focus15386

Section 2: Author's guidelines

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References

Cite references in numerical order in the text, in superscript format (Format> Font> Click superscript). Please do not use brackets or do not use the foot note function of MS Word.

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List all authors when there are six or fewer; when there are seven or more, list the first three, then ";et al."; When citing URLs to web documents, place in the reference list, and use the following format: Authors of document (if available). Title of document (if available). URL. (Accessed [date]).

The following are sample references:

1. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process: volume assessment by 3-

dimensional reconstruction by high-resolutional CT scanning. Otolaryngol Head Neck Surg. 2005 Mar;132(3):429-34.

2. Polgreen PM, Diekema DJ, Vandeberg J, Wiblin RT, Chen YY, David S, et al. Risk factors for groin wound infection after femoral artery catheterization: a case-control study. Infect Control Hosp Epidemiol [Internet]. 2006 Jan [cited 2007 Jan 5];27(1):34-7. Available from: http://www.journals.uchicago.edu/ICHE/journal/issues/v27n1/2004069/2004069.web. pdf.

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Tables should be self-explanatory, clearly organised, and supplemental to the text of the manuscript. Each table should include a clear descriptive title on top and numbered in Roman numerals (I, II, etc) in order of its appearance as called out in text. Tables must me inserted in the correct position in the text. Authors should place explanatory matter in footnotes, not in the heading. Explain in footnotes all non-standard abbreviations.

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10. All numbers below ten, without percentages or units, must be written in words.
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Section 3: Draft article

A survey of adult patients requiring neurosurgery at a central hospital

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Key words: neuroanaesthesia database, neurosurgery, peri-operative care.

Abstract

Background

Data pertaining to all subsets of neurosurgical patients admitted to South African hospitals is lacking. The aim of this study was to survey adult patients requiring neurosurgery at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Methods

A retrospective survey of the REDCap neuroanaesthesia database was conducted. Consecutive data were extracted for 2016 and 2017. Data described the pre-operative assessment, intra-operative anaesthetic management and post-operative status of patients undergoing elective and emergency neurosurgical procedures.

Results

The database entries of 873 patients were included in the study. Most of the patients, 622 (72.1%) were male, 558 (63.9%) received emergency surgery, and 337 (38.6%) patients had traumatic brain injury (TBI). The severe TBI incidence was 45.1%. The predominant anaesthetic technique was an intravenous propofol induction 629 (72.1%) and sevoflurane maintenance 539 (61.7%). Marked haemodynamic instability occurred in 208 (23.8%) patients, mandating either vasopressor 99 (47.6%) or inotropic 109 (52.4%) support. Seizure prophylaxis was only given to 39 (4.5%) patients. Steroids were administered to 134 (39.8%) TBI patients. Significantly more elective surgery patients, 224 (71.1%) were extubated immediately post-operatively ($p<0.0001$). However, the in-hospital mortality among patients did not differ significantly between those who had elective 30 (9.5%) or emergency surgery 47 (8.4%, $p=0.6697$). In-hospital mortality was higher for patients having cranial surgery 61 (9.0%) compared to spinal surgery 6 (6.4%), but this difference was not statistically significant ($p=0.3926$).

Conclusion

The frequent administration of steroids to TBI patients at CMJAH is concerning but highlights the importance of utilising databases for quality improvement purposes. The unexpected mortality finding in this study between elective and emergency cases may be explained by the higher ASA classification of elective patients. This study contributes to the understanding of neurosurgical patient peri-operative care.

Introduction

The Institute of Medicine (1), defines health care quality as “the degree to which health care services for individuals and populations increases the likelihood of desired health outcomes and are consistent with current professional knowledge …”. The field of neurosurgery is a speciality affiliated with high cost and expensive advanced technology (2). There is a need to establish a validated approach to measure the quality of neurosurgical care (3). There has been an increasing focus in the neurosurgical literature to explore suitable surrogate markers of the quality of care received by neurosurgical patients (4).

South Africa has a unique quadruple burden of disease profile. This encompasses Human Immunodeficiency Virus (HIV) and tuberculosis, other communicable diseases, non-communicable diseases, and trauma (5). There is limited literature evaluating the profile of neurosurgical patients in South Africa, however, a few examples exist. An outdated 1991, contextually relevant study reported an estimated incidence of traumatic brain injury (TBI) in Johannesburg of 316 per 100 000 (6). The TBI characteristics of patients in a Pietermaritzburg study is a contemporary example (7). Regarding the paediatric population, the profile of patients at Red Cross War Memorial Children Hospital in Cape Town and Inkosi Albert Luthuli Central Hospital in KwaZulu Natal have been described (8, 9).

In South Africa, the move towards an increased emphasis on quality has been reflected in recent reforms. The National Development Plan identifies “quality health care for all” as a key priority (10). Stemming from this, the National Health Insurance plan intends on investing in quality improvement, cognisant that the quality of care provided in the public sector may be of concern (11). As such there is a direct imperative to strengthen quality measurement in South Africa (12). Databases are fundamental in validating the appropriateness of existing quality metrics as well as elucidating novel neurosurgical specific quality indicators (4).

Naidoo (12) noted in an editorial, “SA [South Africa] does not have a TBI databank, and contemporaneous studies on overall incidence and prevalence of TBI are lacking.” The author went on to comment, “SA needs improved and current TBI epidemiological data to develop protocols appropriate to our unique set of conditions …" (12). Data pertaining to all subsets of neurosurgical patients admitted to South African hospitals is demonstrably lacking. Electronic databases have emerged as important mechanisms to define, measure and promote health care quality (13-15). The aim of this study was to survey adult patients requiring neurosurgery at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH).

Methods

A retrospective, contextual, descriptive survey of the REDCap neuroanaesthesia Database was conducted at CMJAH. Approval to conduct the study was obtained from the Human Research Ethics Committee (Medical) (M180130), and other relevant authorities.

All patients 16 years and older captured on the database from 1 January 2016 to 31 December 2017 were included in the study. For patients having undergone multiple procedures throughout their hospital course, only the index data entry for such patients was included.

The data were extracted from the database in a consecutive manner. Data for incomplete entries were retrieved from source documents, including admission books, anaesthetic records, and laboratory records. The data captured on the database included: patient demographics, pre-operative neurological assessment, intra-operative anaesthetic management, and post-operative status. An entry was deemed inadequately completed if it failed to capture any of the following: date of surgery, patient age, gender, procedure undergone, and whether the procedure was performed electively or emergently. Inadequately completed entries were excluded from the final analysis. Data were collected by one author (L.I).

Data were analysed using Microsoft Exel® and Graftpad Instat™. Categorical variables are described using frequencies and percentages. Continuous variables are described using means, standard deviations, and ranges. Comparisons were made using Chi-square tests. A p-value of <0.05 was considered statistically significant.

Results

The database entries of 873 patients were included in the study. The derivation of the study sample is given in Figure 1, and patient characteristics are shown in Table 1. The mean (SD) age of patients was 43.2 (15.8), with a range of 16 – 88 years. Emergency procedures were performed in 558 (63.9%) patients, including 509 (91.2%) cranial surgeries, 8 (1.4%) spine surgeries, and 41 (7.6%) others. Trauma patients accounted for 340 (61.0%) of these emergency procedures, of which 314 (92.3%) were cranial surgeries. Comorbid conditions were documented in 355 (40.7%) patients, of which 116 (32.7%) had >1 comorbidity, ranging between 2 – 5 additional conditions. Cardiovascular comorbidities were reported in 202 (23.1%) patients, of which 154 (76.2%) were hypertensive.

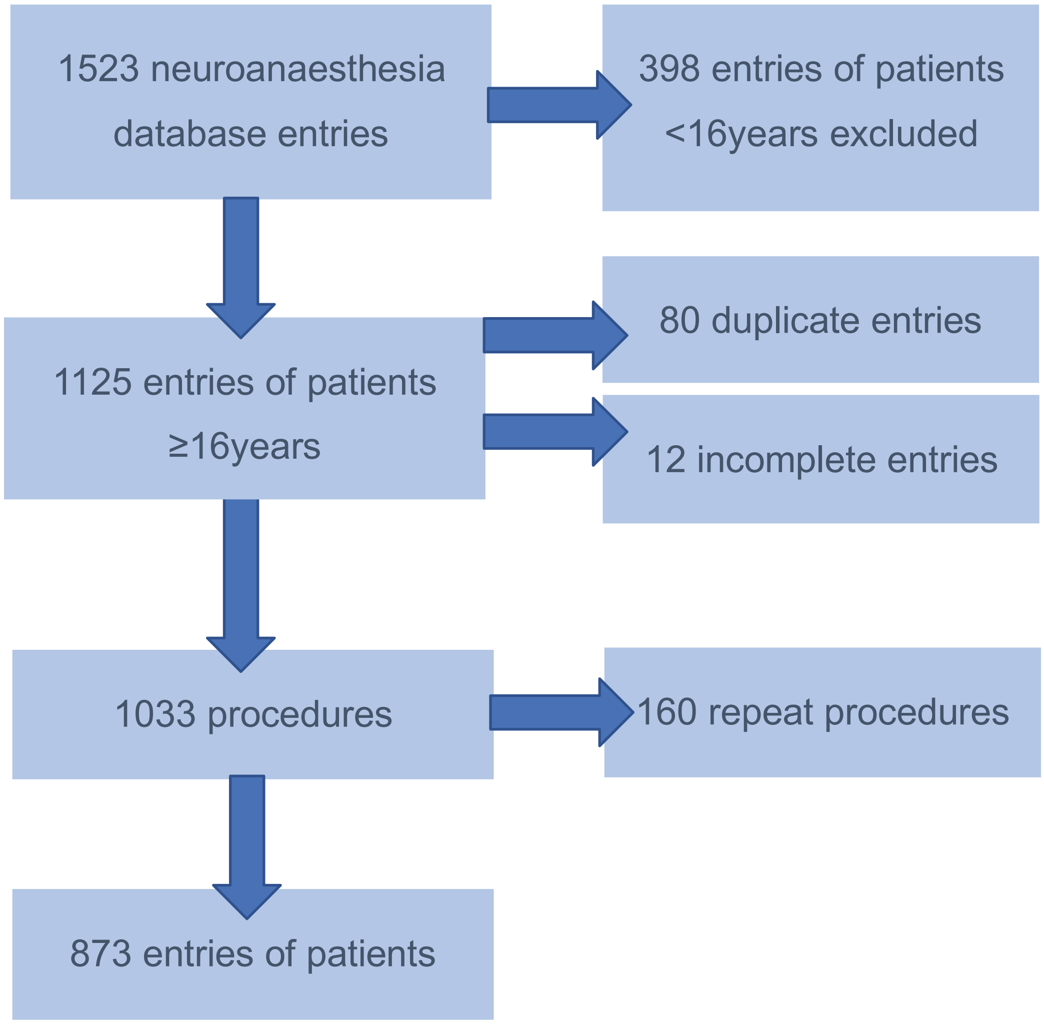

Figure 1: Derivation of study sample

Table 1: Characteristics of patients

Demographics	Number	Percentage
Gender		
• Male	622	71.2
• Female	251	28.8
ASA classification*		
• 1	132	15.1
• 2	229	26.2
• 3	389	44.6
• 4	114	13.1
• 5	9	1.0
Type of surgery		
• Elective	315	36.1
• Emergency	558	63.9
Neurosurgical procedure		
• Cranial	675	77.3
• Spinal	94	10.8
• Other	50	5.7
• Interventional neuroradiology	54	6.2
Neuropathology		
• Congenital	13	1.4
• Tumour	169	19.4
• Infective	78	8.9
• Vascular	131	15.0
• Trauma	383	43.9
• Iatrogenic	5	0.6
• Other	94	10.8
Comorbid conditions		
• Cardiovascular	202	23.1
• Respiratory	112	12.8
• Endocrine	65	7.4
• Renal	24	2.7
• Hepatic	6	0.7
• HIV positive status	109	12.5

The patients’ pre-operative neurological assessment is shown in Table 2. Four hundred and five (46.4%) patients had a Glasgow Coma Scale (GCS) of 15. Of the 337 TBI patients, 137 (40.7%) were classed as mild, 48 (14.2%) moderate, and 152 (45.1%) severe, respectively. A positive history of neurological symptomatology was present in 571 (65.4%) patients, of which 97 (17.0%) patients experienced >1 symptom with a range of 2 – 3. Computed tomography brain scans were available for 813 (93.1%) patients and 436 (53.6%) patients had multiple radiological features documented with a range of 2 – 5 features per patient.

The patients’ pre-operative mean (SD) haemoglobin was 12.8 (2.5) with a range of 1.8 – 20 mg/dL. One hundred and forty-seven (16.8%) patients presented to theatre with a haemoglobin <10 mg/dL. Trauma was the underlying aetiology for a haemoglobin <10 mg/dL in 48 (32.7%) of these patients. Transfusion of red packed cells was noted for 18 (37.5%) of these trauma patients. Fourteen (0.05%) trauma patients with an initial haemoglobin >10mg/dL received a blood transfusion during their index procedure.

Table 2: Pre-operative neurological assessment

Neurological parameter	Number	Percentage
GCS		
• ≤8	224	25.7
• 9 – 12	108	12.4
• 13 – 15	541	61.9
Pupils equal		
• Yes	399	45.7
• No	70	8.0
• Unable to assess/not done	404	46.3
Speech affected		
• Yes	61	7.0
• No	291	33.3
• Unable to assess/not done	521	59.7
Positive history of neurological symptoms		
• Loss of consciousness	427	48.9
• Headache	165	18.9
• Nausea and vomiting	44	5.0
• Seizure	59	6.8
Neurological deficit		
• Motor deficit present	199	22.8
• Motor deficit absent	424	48.6
• Unable to assess/not done	250	28.6
• Sensory deficit present	80	9.2
• Sensory deficit absent	484	55.4
• Unable to assess/not done	309	35.4
• Cranial nerve deficit present	42	4.8
• Cranial nerve deficit absent	530	60.7
• Unable to assess/not done	301	34.5

Intra-operative anaesthetic assessment and management are shown in Table 3. An intravenous induction was performed in 629 (72.1%) patients, and a sevoflurane maintenance technique was used most commonly in 539 (61.7%) patients. All patients had standard ASA monitoring applied, and arterial lines were placed for invasive blood pressure monitoring in 635 (72.7%) patients.

Multiple attempts to secure the airway occurred in 29 (4.5%) patients. A difficult airway was anticipated by pre-operative assessment in all 6 patients who had ≥ 3 intubation attempts. None of these patients were presenting for cervical spine surgery. An introducer was employed in an attempt to secure the airway in all these patients. Variable use of other airway adjuncts was used in the form of a bougie (1), laryngeal mask airway (2), video laryngoscope (2), and other undefined airway adjuncts (1) to manage the airway of these patients. Of the 22 patients who had 2 intubation attempts, 7 (31.8%) had cervical spine pathology. Video laryngoscopy was used in 5 (71.4%) of these patients, and 1 (14.3%) patient was intubated with a fibreoptic bronchoscope.

Multiple pharmacological agents were administered for a given anaesthetic. Fentanyl was the opioid of choice given to 693 (79.4%) patients, followed by morphine and alfentanil in 353 (40.4%) and 207 (23.7%) patients respectively, in isolation or combination. Marked haemodynamic instability requiring vasopressor or inotropic support occurred in 208 (23.8%) patients. In these patients, phenylephrine infusions were started in 99 (47.6%) patients, and adrenaline infusions were started in 109 (52.4%) patients. Sixteen patients (7.7%) received both phenylephrine and adrenaline infusions intra-operatively. Patients requiring adrenaline infusions were presenting most frequently for emergency surgery 87 (79.8%), had cranial procedures 98 (89.9%), were ASA class ≥III 87 (79.8%), and had a GCS ≤8 60 (55.0%).

Anti-convulsant, anti-emetic and anti-hypertensive use was limited. The specific agents utilised most frequently per drug class were phenytoin in 42 of 47 (89.4%) patients, ondansetron in 38 of 42 (90.5%) patients, and labetalol in 4 of 5 (80.0%) patients. Anti-convulsants were administered for seizure prophylaxis in 39 (83.0%) of patients receiving this medication. The remaining 8 (17.0%) patients who received an anti- convulsant intra-operatively had a positive history of seizures preceding their surgery. Dexamethasone was administered to 409 (46.8%) patients. Of the 337 TBI patients, 134 (39.8%) were given a dexamethasone dose intra-operatively.

Table 3: Intra-operative anaesthetic assessment and management

Characteristic	Number	Percentage
Airway difficulty anticipated		
• No	572	65.5
• Yes	73	8.4
• ETT in situ	228	26.1
Mallampatti score		
• 1	212	32.9
• 2	316	49.0
• 3	67	10.4
• 4	13	2.0
• Unable to assess/not done	37	5.7
Intubation attempts		
• 1	610	94.5
• 2	23	3.6
• 3	5	0.8
• >3	1	0.2
• Not attempted	6	0.9
Anaesthetic induction technique		
• Intravenous induction	629	72.1
• Inhalational induction	223	25.5
• Co-induction	21	2.4
Pharmacological agents		
• Opioids	861	98.6
• Vasopressors	562	64.4
• Anti-convulsants	47	5.4
• Anti-emetics	42	4.8
• Anti-hypertensives	5	0.6
• Mannitol	121	14.0
• Dexamethasone	409	46.8

The post-operative characteristics of adult patients undergoing neurosurgical procedures are shown in Table 4. Fifteen (1.7%) patients developed new-onset neurology in the immediate post-operative period following extubation. More than half of these 9 (60.0%) patients were ASA class ≥III. Stratified by procedure and underlying neuropathology, 3 (20.0%) patients had undergone a neuro-interventional procedure for vascular pathology, 2 (13.3%) were thoracic spine surgeries for tumours, 2 (13.3%) had ventriculoperitoneal shunt insertions. The remaining 8 (53.4%) patients underwent supratentorial craniotomies, 2 had mild

TBI, 4 had tumours, 1 an abscess and 1 had an undefined surgical indication. Vasopressor or inotropic support was not administered to any of these patients.

Patients having received an intra-operative adrenaline infusion were less frequently extubated. Ten (9.2%) patients who required an intra-operative adrenaline infusion were extubated. The relationship between the number of patients extubated post-emergency versus elective surgery was significant, (X^2 [1] = 51.79, p<0.0001) with 224 (71.1%) patients having undergone elective procedures being extubated immediately post-operatively. The proportion of in-hospital mortality among patients did not differ significantly between those who had elective or emergency surgery (X^2 [1] = 0.182, p=0.6697). In-hospital mortality was higher for patients having cranial surgery 61 (9.0%) compared to spinal surgery 6 (6.4%), but this difference was not statistically significant (X^2 [1] = 0.7307, p=0.3926). The in-hospital mortality for TBI patients was (29) 8.6% and for severe TBI was (24) 15.8%. Severe TBI accounted for 82.3% of all TBI mortality.

Table 4: The post-operative characteristics

Characteristic	Elective (n=315) n (%)	Emergency (n=558) n (%)	Total cases (n=873) n (%)
Extubated post-operatively	224 (71.1)	256 (45.9)	480 (55.0)
Reason for non-extubation			
• Pre-operative GCS	22 (7.0)	151 (27.1)	173 (19.8)
• Intubated pre-operatively	33 (10.5)	129 (23.1)	162 (18.6)
New neurological deficit	9 (2.9)	6 (1.1)	15 (1.7)
Post-operative destination			
• Neurosurgery ward	42 (13.3)	60 (10.5)	102 (11.7)
• High care area	86 (27.3)	131 (23.5)	217 (24.9)
• Intensive care unit (ICU)	187 (59.4)	365 (65.6)	552 (63.2)
• General ward	0 (0.0)	2 (0.4)	2 (0.2)
In-hospital mortality	30 (9.5)	47 (8.4)	77 (8.8)
Discharge location			
• Referring hospital	41 (14.5)	230 (42.5)	271 (34.0)
• Home	210 (73.7)	208 (38.4)	418 (52.5)
• Other	5 (1.6)	1 (0.2)	6 (0.8)
• Unknown	29 (10.2)	72 (13.3)	101 (12.7)

Discussion

CMJAH is a central hospital offering a wide range of secondary, tertiary, and quaternary services. The 1 088-bed hospital serves as a referral hospital for a number of district and regional level hospitals, and for other African countries. The neurosurgical unit has a 20-bed capacity, 12 high care beds and 8 ventilator-equipped ICU beds. Four permanent neurosurgical consultants, a part-time intensivist, and 5 – 8 rotating neurosurgical registrars are based in the unit. One dedicated elective neurosurgical operating theatre functions four working days per week. Three emergency theatres are continuously operational and serve all surgical disciplines, barring obstetric and cardiac surgery.

A survey of the peri-operative care of neurosurgical patients, involving a spectrum of major neuropathology, was not identified in other settings. This limits the comparability of findings in this study with the existing national and international literature.

This study showed a predominance of male patients (71.2%). Of our TBI patients 92.9% were male, in keeping with the literature consistently reporting disproportionately more male TBI patients (7, 16 -18). This likely reflects high-risk behaviour patterns among young males (14, 19).

Emergency procedure rates (63.9%) in this study are similar to those described in the Neurosurgical National Audit Program in the United Kingdom and Ireland (20). For example, at John Radcliffe Hospital, a 61.7% adult emergency neurosurgery rate was reported for a 12-month period in 2018 – 2019 (20). A greater proportion of emergency procedures is expected in this study due to the high prevalence of trauma in South Africa (21). The implications of a higher caseload of emergency surgeries are numerous. Importantly, there is an inherent increased cost to all stakeholders (22), increased surgical and anaesthetic risk, and limited time for pre-operative patient optimisation (23).

This study showed that cranial surgeries were more frequently performed as emergency procedures (75.4%) whereas spinal surgery was more frequently performed electively (91.5%). Similarly, hospitals included in the Neurosurgical National Audit Program mainly perform spinal surgeries as elective procedures (79.1%) (20). In the South African context, the pattern of traumatic injury may explain the findings in this study. Accurate contemporary incidence data is not available, but TBI and traumatic spinal cord injury crude incidence rates of 316 per 100 000 (6) and 75.6 per million (24), respectively, have been reported. The findings of this study support the presumption that proportionately lower emergency spinal surgery numbers reflect a relatively lower incidence of traumatic spinal cord injury compared to TBI at CMJAH.

In this study, cranial surgeries (77.3%) outnumbered spinal surgeries (10.8%). Rock et al. (25) used the American College of Surgeons National Surgical Quality Improvement Program database and reviewed cases performed by neurosurgeons over 10 years. They identified 21.8% were cranial surgeries and 78.2% were spinal surgeries. CMJAH has a dedicated orthopaedic spine unit, these patients do not have neurological involvement and are not captured on the database. However, these omitted surgeries do not account for the large variation in practice observed. The discrepancy between spinal surgery numbers in this study and those identified by Rock et al. (25) may highlight that degenerative conditions, commonly the indication for spine surgery (26), are not a South African health priority (5).

TBI is an ongoing global health concern (16). In this study, 45.1% of TBI patients had severe TBI. This is similar to the severe TBI operative rates (40.0%) (7) in Pietermaritzburg and higher than the 26.4% reported in an Iceland study (18). The incidence of severe TBI is expected to be higher in low-middle income countries owing to a high occurrence of motor- and pedestrian-vehicle accidents (27), interpersonal violence (28), and war-related conflicts (17) spurred by low-level education (27), high unemployment rates, and cultural tensions (17, 28). Furthermore, TBI patients in low-middle income countries are suspected to have poorer outcomes due to competitive access to scarce pre-hospital, specialist in-hospital, and post-discharge injury care (7, 29, 30). In the South African context, the severe TBI rate shown in this study is concerning. TBI places a high demand on limited resources, including neurorehabilitation (31, 32).

In South Africa, HIV prevalence among the general population is 20.4% (33), however, a lower HIV prevalence of 12.5% was reported in this study. This low number of HIV positive patients in the study does not reflect ICU and high care admission discrimination. Not all neurosurgical patients at CMJAH are routinely tested for HIV. HIV status is either volunteered by the patient, or a test is performed if clinical indication exists. The true prevalence of HIV in this population is likely greater than that shown by the study.

There has been an ongoing debate regarding the superiority of total intravenous anaesthesia (TIVA) compared to a volatile-based anaesthetic technique in neurosurgical patients (34, 35, 36). At CMJAH the predominant technique was intravenous induction (72.1%) and volatile maintenance (61.7%). Possible explanations may be, the anaesthetists' familiarity with volatile-based anaesthesia, cost-containment concerns regarding the use of TIVA for prolonged surgeries, and inconsistent availability of disposables for depth of anaesthesia monitors. The anaesthetic technique used at CMJAH is in alignment with international practice (34, 36 – 38).

Other areas of controversial practice relate to the use of hypertonic solutions and anti-epileptic drugs. The superiority of either hypertonic saline or mannitol for the treatment of raised intracranial pressure has been questioned (39). Mannitol was the hypertonic solution of choice at CMJAH. Historically mannitol is the available hypertonic agent at CMJAH and there is data to support its use (40, 41). A systematic review showed limited clinical benefit of prophylactic anti-convulsant administration in the prevention of post-craniotomy seizures (42). In TBI patients, there is evidence to support the use of phenytoin (43). In this study, an anti-convulsant, most commonly phenytoin, was administered for seizure prophylaxis in only 4.5% of patients.

Steroid administration is common in the peri-operative care of tumour patients with concurrent cerebral oedema (44). The Brain Trauma Foundation states that steroid administration to TBI patients is harmful and is not recommended (43). In this study, 39.8% of TBI patients were given dexamethasone intra-operatively. This may reflect post-operative nausea and vomiting prophylaxis practices. A randomised control trial has shown the detrimental hyperglycaemic effects of dexamethasone administration at prophylactic doses (45). It is recommended that the department investigates the nature of this practice and institute appropriate measures, including education, to address the problem.

Mortality rates are commonly employed outcome metrics to evaluate the quality of care (4). The in-hospital mortality rate in this study was 8.8%. Stratified by cranial or spinal surgery in this study, the mortality rates were 9.0% and 6.4%, respectively. In this study, the overall TBI mortality was 8.6%, and the mortality for severe TBI was 15.8%. These figures appeared to be lower than the reported mortality rates of 25.8% and 33.4% for Ugandan (19) and Pietermaritzburg (7) TBI studies, respectively. Unexpectedly, in this study, the proportion of in-hospital mortality among patients did not differ significantly between those who had elective or emergency surgery. A higher ASA class among patients presenting for elective neurosurgery may explain this finding.

Survival to discharge or transfer does not delineate which patients survived neurologically intact, with mild deficit or with profound neurological disability. Long term outcomes following discharge would be more elucidating and are recommended for future research. A further limitation was the retrospective acquisition of data and hence the concern of the accuracy of collated data. Additionally, the contextual nature of the sample limits the generalisation of findings.

Conclusion

Databases are being ear-marked as instrumental tools to measure the quality of care delivered to patients (3, 13). At CMJAH the frequent administration of steroids to TBI patients is concerning and a recommendation to further analyse the issue and institute corrective measures has been made. Comparability of mortality rates in this study with that of others is limited by inter-study methodological differences. However, the unexpected mortality finding in this study between elective and emergency cases may be explained by the higher ASA classification of elective patients. This study contributes to the understanding of neurosurgical patient peri-operative care.

Conflict of interest

The authors declare that we have no financial or personal relationships which may have inappropriately influenced us in writing this paper.

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References

1. Institute of Medicine, Committee on the Quality of Health Care in America. Crossing the quality chasm: A new health system for the 21st Century. National Academy Press; 2001. [Accessed: 26 August 2017] Available at: http://www.nap.edu/catalog/10027.html

2. Barker FG II. Pursuing excellence in healthcare delivery: American neurosurgery. Clin Neurosurg. 2010;57:60-8.

3. Lau CY. Quality improvement tools and processes. Neurosurg Clin N Am. 2015;26(2):177-87.doi:10.1016/j.nec.2014.11.016

4. Schipmann S, Schwake M, Suero Molina E, Roeder N, Steudel WI, Warneke N, et al. Quality indicators in cranial neurosurgery: Which are presently substantiated? A systematic review. World Neurosurg. 2017;104:104-12.doi:10.1016/j.wneu.2017.03.111

5. Bradshaw D, Nannan N, Laubscher R, Groenewald P, Joubert J, Nojilana B, et al. South African National Burden of Disease Study 2000. Estimates of provincial mortality: Summary report. Medical Research Council; 2006. [Accessed: 12 September 2017] Available at: https://www.samrc.ac.za/sites/default/files/files/2017-07-03/estimate.pdf

6. Nell V, Brown DSO. Epidemiology of traumatic brain injury in Johannesburg II. Morbidity, mortality and etiology. Soc Sci Med. 1991;33(3):289-96.doi:10.1016/0277-9536(91)90363-H

7. Jerome E, Laing GL, Bruce JL, Sartorius B, Brysiewicz P, Clarke DL. An audit of traumatic brain injury (TBI) in a busy developing-world trauma service exposes a significant deficit in resources available to manage severe TBI. S Afr Med J. 2017;107(7):621-25 doi:10.7196/SAMJ.2017.v107i7.10562

8. Schrieff LE, Thomas KGF, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children Hospital, 2006 – 2011. S Afr Med J. 2013;103(9):616-20.doi:10.7196/SAMJ.7137

9. Allopi K, Padayachee L. An audit of the perioperative anaesthetic management of ventriculoperitoneal shunt insertion in the paediatric population at Inkosi Albert Luthuli Central Hospital. S Afr J Anaesth Analg. 2014;20(5):209-13.doi:10.1080/22201181.2014.979635

10. National Planning Commission. National Development Plan 2030. Our future: make it work. Pretoria: 2012 [Accessed 25 August 2017]. Available at: http://www..poa.gov.za/news/Documents/NPC%20National%20Development%20Plan%20Vision%202030%20-lo-res.pdf.

11. National Department of Health, Republic of South Africa. National Health Insurance for South Africa: Towards universal health coverage. Pretoria: 2017 [Accessed 29 November 2017]. Available at: www.health.gov.za/index.php/nhi?download=2257:white-paper-nhi-2017

12. Naidoo D. Traumatic brain injury: The South African landscape. S Afr Med J. 2013;103(9): 613-4.doi:10.7196/SAMJ.7325

13. Asher AL, Parker SL, Rolston JD, Selden NR, McGirt MJ. Using clinical registries to improve the quality of neurosurgical care. Neurosurg Clin N Am. 2015;26(2):253-63.doi:10.1016/j.nec.2014.11.010

14. Bradford NK. Interventions to increase the use of electronic health information by healthcare practitioners to improve clinical practice and patient outcomes. Int J EBH. 2016;14(3):136-7.doi:10.1097/xeb.0000000000000074

15. Vener DF, Pasquali SK, Mossad EB. Anesthesia and databases: Pediatric cardiac disease as a role model. Anesth Analg. 2017;124(2):572-81.doi:10.1213/ane.0000000000001448

16. Nguyen R, Fiest KM, McChesney J, Kwon C-S, Jette N, Frolkis AD, et al. The international incidence of traumatic brain injury: A systematic review and meta-analysis. Can J Neuro Sci. 2016;43(6):774-85.doi:10.1017/cjn.2016.290

17. Abou-Abbass H, Bahmad H, Ghandour H, Fares J, Wazzi-Mkahal R, Yacoub B, et al. Epidemiology and clinical characteristics of traumatic brain injury in Lebanon: A systematic review. Medicine. 2016;95(47):e5342.doi:10.1097/MD.0000000000005342

18. Jonsdottir GM, Lund SH, Snorradottir B, Karason S, Olafsson IH, Reynisson K, et al. A population-based study on epidemiology of intensive care unit treated traumatic brain injury in Iceland. Acta Anaesthesiol Scand. 2017;61(4):408-17.doi:10.1111/aas.12869

19. Mehmood A, Zia N, Hoe C, Kobusingye O, Ssenyojo H, Hyder AA. Traumatic brain injury in Uganda: Exploring the use of a hospital based registry for measuring burden and outcomes. BMC Res Notes. 2018;11(1):299-305.doi:10.1186/s13104-018-3419-1.

20. Society of British Neurological Surgeons (2020) Neurosurgical National Audit Program [Accessed 28 January 2021] Available at: https://www.nnap.org.uk/Hospital?shaCode=SC
21. Williams HM, Erlank EC. Traumatic incident reduction: A suitable technique for South African social work practice settings. Health SA. 2019;24(0):a1106.doi:10.4102/hsag.v24i0.1106
22. Haider AH, Obirieze A, Velopulos CG, Richard P, Latif A, Scott VK, et al. Incremental cost of emergency versus elective surgery. Ann Surg. 2015;262(2):260-6.doi:10.1097/SLA.0000000000001080
23. Gray LD, Morris CG. Organisation and planning of anaesthesia for emergency surgery. Anaesthesia. 2013;68(Suppl.1):3-13.doi:10.1111/anae.12054
24. Joseph C, Delcarme A, Vlok I, Wahman K, Phillips J, Nilsson Wikmar L. Incidence and aetiology of traumatic spinal cord injury in Cape Town, South Africa: A prospective, population-based study. Spinal Cord. 2015;53:692–6.doi:10.1038/sc.2015.51
25. Rock AK, Opalak CF, Workman KG, Broaddus WC. Safety outcomes following spine and cranial neurosurgery: Evidence from the National Surgical Quality Improvement Program. J Neurosurg Anesthesiol. 2018;30(4):328-36.doi:10.1097/ANA.0000000000000474
26. Martin BI, Lurie JD, Tosteson AN, Deyo RA, Tosteson TD, Weinstein JN, et al. Indications for spine surgery: Validation of an administrative coding algorithm to classify degenerative diagnoses. Spine. 2014;39(9):769-79.doi:10.1097/BRS.0000000000000275
27. Boniface R, Lugazia ER, Ntungi AM, Kiloloma O. Management and outcome of traumatic brain injury patients at Muhimbili Orthopaedic Institute Dar es Salaam, Tanzania. Pan Afr Med J. 2017;26:140.doi:10.11604/pamj.2017.26.140.10345
28. Silber G, Geffen N. Race, class and violent crime in South Africa: Dispelling the 'Huntley Thesis. South African Crime Quarterly. 2016; 30(30):35-43. doi:10.17159/2413-3108/2009/v0i30a897
29. De Silva MJ, Roberts I, Perel P, Edwards P, Kenward MG, Fernandes J, et al. Patient outcome after traumatic brain injury in high-, middle- and low-income countries: Analysis of data on 8927 patients in 46 countries. Int J Epidemiol. 2009;38(2):452-8.doi:10.1093/ije/dyn189.

30. Samanamalee S, Sigera PC, De Silva AP, Thilakasiri K, Rashan A, Wadanambi S, et al. Traumatic brain injury (TBI) outcomes in an LMIC tertiary care centre and performance of trauma scores. BMC Anesthesiol. 2018;18(1):4-11.doi:10.1186/s12871-017-0463-7
31. Demir Y, Köroğlu Ö, Tekin E, Adıgüzel E, Kesikburun S, Güzelküçük Ü, et al. Factors affecting functional outcome in patients with traumatic brain injury sequelae: Our single-center experiences on brain injury rehabilitation. Turk J Phys Med Rehabil. 2018;65(1):67-73.doi:10.5606/tftrd.2019.2281
32. Oberholzer M, Müri RM. Neurorehabilitation of traumatic brain injury (TBI): A clinical review. Med Sci (Basel). 2019;7(3):47-56.doi: 10.3390/medsci7030047
33. Human Sciences Research Council (2018) The Fifth South African National HIV Prevalence, Incidence, Behaviour and Communication Survey, 2017. [Accessed 28 January 2021] Available at: https://www.aidshealth.org/wp-content/uploads/2018/08/hsrc-survey-2018-summary.pdf.
34. Chui J, Mariappan R, Mehta J, Manninen P, Venkatraghavan L. Comparison of propofol and volatile agents for maintenance of anesthesia during elective craniotomy procedures: Systematic review and meta-analysis. Can J Anaesth. 2014;61(4):347-56.doi:10.1007/s12630-014-0118-9.
35. Necib S, Tubach F, Peuch C, LeBihan E, Samain E, Mantz J, et al. PROMIFLUNIL trial group. Recovery from anesthesia after craniotomy for supratentorial tumors: Comparison of propofol-remifentanil and sevoflurane-sufentanil (the PROMIFLUNIL trial). J Neurosurg Anesthesiol. 2014;26(1):37-44.doi:10.1097/ANA.0b013e31829cc2d6
36. Schmoch T, Jungk C, Bruckner T, Haag S, Zweckberger K, von Deimling A, et al. The anesthetist's choice of inhalational vs. intravenous anesthetics has no impact on survival of glioblastoma patients. Neurosurg Rev. 2020.doi:10.1007/s10143-020-01452-7
37. Prabhakar H, Sharma M, Jain V, Ali Z, Bithal P, Dash H. Controversial issues in neuroanaesthesia and their current practice in India: A questionnaire survey. Indian J Anaesth. 2008;52(6):823-28.
38. Wan Hassan WMN, Mohd Nasir Y, Mohamad Zaini RH, Wan Muhd Shukeri WF. Target-controlled infusion propofol versus sevoflurane anaesthesia for emergency traumatic brain surgery: Comparison of the outcomes. Malays J Med Sci. 2017;24(5):73-82.doi:10.21315/mjms2017.24.5.8

39. Pasternak JJ, Lanier WL. Neuroanesthesiology update. J Neurosurg Anesthesiol. 2015;27(2):87-122.doi:10.1097/ana.0000000000000167
40. Li M, Chen T, Chen SD, Cai J, Hu YH. Comparison of equimolar doses of mannitol and hypertonic saline for the treatment of elevated intracranial pressure after traumatic brain injury: a systematic review and meta-analysis. Medicine. 2015;94(17):736-51.doi:10.1097/md.0000000000000736
41. Ali A, Tetik A, Sabanci PA, Altun D, Sivrikoz N, Abdullah T, et al. Comparison of 3% hypertonic saline and 20% mannitol for reducing intracranial pressure in patients undergoing supratentorial brain tumor surgery: A randomized, double-blind clinical trial. J Neurosurg Anesthesiol. 2018;30:171–178.doi:10.1097/ANA.0000000000000446
42. Greenhalgh J, Weston J, Dundar Y, Nevitt SJ, Marson AG. Antiepileptic drugs as prophylaxis for postcraniotomy seizures. Cochrane Database Syst Rev 2020, Issue 4. Art. No.: CD007286.doi:10.1002/14651858.CD007286.pub5.
43. Carney N, Totten AM, O'Reilly C, Ullman JS, Hawryluk JWG, Bell MJ, et al. Guidelines for the management of severe traumatic brain injury, fourth edition. Neurosurgery. 2017;80(1):6-15.doi:10.1227/neu.0000000000001432
44. Dietrich J, Rao K, Pastorino S, Kesari S. Corticosteroids in brain cancer patients: Benefits and pitfalls. Expert Rev Clin Pharmacol. 2011;4(2):233-42.doi:10.1586/ecp.11.1
45. Tien M, Gan TJ, Dhakal I, White WD, Olufolabi AJ, Fink R, et al. The effect of anti-emetic doses of dexamethasone on postoperative blood glucose levels in non-diabetic and diabetic patients: A prospective randomised controlled study. Anaesthesia. 2016;71(9):1037-43.doi: 10.1111/anae.13544.

Section 4: Proposal

A survey of adult patients requiring neurosurgery at a central hospital

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4.1 Introduction and problem statement

The Institute of Medicine (1), defines health care quality as "the degree to which health care services for individuals and populations increases the likelihood of desired health outcomes and are consistent with current professional knowledge…". The field of neurosurgery is a speciality affiliated with high cost and expensive advanced technology (2). There is a need to establish a validated approach to measure the quality of neurosurgical care (3). There has been an increasing focus in the neurosurgical literature to explore suitable surrogate markers of the quality of care received by neurosurgical patients (4).

Electronic databases have emerged as important mechanisms to define, measure and promote health care quality (5-7). Such databases are cost-effective and scalable tools that collect uniform data evaluating specified parameters for a designated population (5). Numerous authors highlight the Society of Thoracic Surgeons (STS) National Database and the National Neurosurgery Quality and Outcomes Database (N^2QOD) as examples of successful clinical registries (5, 6, 8, 9). Importance of collating these data speaks to informing quality improvement initiatives, service delivery restructuring, health service training and benchmarking purposes (10, 11).

By defining the population sub-served, institutions are able to advocate for restructuring of service delivery to meet population needs. St. George's Hospital, conducted a retrospective audit which highlighted significant definitive treatment delay in up to 75% of good grade sub-arachnoid haemorrhage patients (12). The described finding translated into advocating for inter-neurosurgical unit collaboration between seven London hospitals to reduce treatment delay times (12). Evaluation of bed occupancy characteristics and theatre utilisation times have spurred efficiency improvements in other settings (13, 14).

Furthermore, the profile of neurosurgical patients dictates scope of practise. More than 50% of the patients treated at Shanghai HuaShan Hospital have brain or spinal tumours. This drives a well-developed neuro-oncology subspecialisation program at this institution (15). A preponderance for oncology in developed nations has been noted elsewhere (16). Moreover, a survival benefit is conferred when surgeries are performed by subspecialists in dedicated institutions (17, 18). Tailored neurosurgical training to local circumstance is well documented (19-21).

Developing nations are privy to a unique pattern of neurosurgical pathologies. Lebanon has a high suspected incidence of traumatic brain injury (TBI) (22). In Africa, a commensurately high TBI incidence rate is expected (23, 24). The distribution of pathology in the paediatric population may be different. Adigun et al. (25) described endoscopic third venticulostomy as the most frequently performed procedure in their setting, followed by meningocoele repair. Paediatric TBI was reported as occurring in 10.5% of the study population (25). This rate is similar to that reported for other African countries (26).

South Africa has a unique quadruple burden of disease profile. This encompasses human immunodeficiency virus and tuberculosis co-infection, other communicable disease, non-communicable disease and trauma (27). Limited literature evaluates the profile of neurosurgical patients in South Africa. A few examples do exist. A pre-democratic 1991 South African study reported an estimated incidence of TBI in Johannesburg of 316 per 100 000 (28). A Red Cross Memorial audit showed a paediatric TBI mortality rate of 14.6% (29). A retrospective description of paediatric ventriculoperitoneal shunt insertions was performed in Kwa-Zulu Natal (30).

In South Africa, the move towards increased emphasis on quality has been reflected in recent reforms. The National Development Plan identifies “quality health care for all” as a key priority for the country (31). Stemming from this, the proposed National Health Insurance plan on universal health coverage acknowledges concerns about the quality of care provided in the public sector and makes clear the intention to invest in quality improvement (32). Directly related to the overarching policy context for quality improvement is the imperative to strengthen quality measurement in South Africa (33).

Providing quality health care is a mandatory pursuit in all settings (2). There is pressure to develop standardised approaches for measuring the quality of care delivered. Neurosurgery is a complex, high risk discipline. Furthermore, a paucity of neurosurgical specific quality indicators exists (4). Databases are fundamental in validating the appropriateness of existing quality metrics as well as elucidating novel neurosurgical specific quality indicators (5).

Naidoo (33) noted in an editorial, “SA [South Africa] does not have a TBI [traumatic brain injury] databank, and contemporaneous studies on overall incidence and prevalence of TBI are lacking.” He then went on to comment, “SA [South Africa] needs improved and current TBI epidemiological data to develop protocols appropriate to our unique set of conditions…” (33). Data pertaining to all subsets of neurosurgical patients admitted to South African hospitals is demonstrably lacking.

The profile of neurosurgical patients and their theatre utilisation at Charlotte Maxeke Johannesburg Academic Hospital (CMJAH) is not known.

4.2 Aim and objectives

4.2.1 Aim

The aim of this study is to survey adult patients requiring neurosurgery at CMJAH.

4.2.2 Objectives

The objectives of this study are to describe**:**

- the demographics of neurosurgical patients
- the pre-operative neurological assessment
- the intra-operative anaesthetic management
- the post-operative status.

The secondary objective of this study is to compare the mortality and functionality of elective versus emergency patients.

4.3 Research assumptions

The following definitions will be used in this study.

Elective: scheduled procedure of non-urgent indication or not life-threatening nature in which pre-operative preparation is permissible.

Emergency: surgical procedure is performed for an urgent or potentially neurologically devastating or life-threatening indication.

Adult: is a person identified or assumed as 16 years and older.

Database: in this study it refers to the password protected REDCap Neuroanaesthesia Database from which the data entries will be extracted. This database was created prior and independently to the study. Since it has not been created for the purpose of the study all database data collection sheet categories, nomenclature and fields are pre-stipulated and not subject to change. Missing data will be sought from source documents i.e. admission books, anaesthetic records and National Health Laboratory Services (NHLS) records.

Anaesthetic Management: In the study is limited to the description of the intra-operative medication administered including opioids, dexmedetomidine, dexamethasone, vasopressors, inotropes, anti-emetics, anti-epileptics and anti-hypertensives. Induction technique and volatile agent selected for anaesthetic maintenance is additionally noted.

Adequately completed database entries: describes the pre-requisite captured information. The mandatory fields to be completed are: patient pathology, date of neurosurgical intervention, type of procedure performed, whether the procedure was performed electively or as an emergency, pre-operative Glasgow Coma Scale (GCS) and post-operative intubation status.

4.4 Demarcation of study field

The study will be conducted at CMJAH, a 1200 bed central hospital, in the Department of Anaesthesiology affiliated with the University of the Witwatersrand. The hospital has 23 theatres of which one is a dedicated elective neurosurgical theatre and three are emergency theatres sub-serving all surgical, non-obstetric disciplines. On average 23 000 operations are done annually, and that includes approximately 150 neurosurgical cases.

4.5 Ethical considerations

Approval to conduct the study will be obtained from the Human Research Ethics Committee (Medical), the Graduate Studies Committee of the University of the Witwatersrand and the National Health Research Committee of Gauteng. Permission to review the REDCap Neuroanaesthesia Database was granted by the database administrator (Appendix 1). Permission to access source documents has been provided by the Head of Department of Anaesthesiology and Neurosurgical ICU (Appendix 1). Application will be made for an online password to access the REDCap Neuroanaesthesia Database once approval to commence data collection has been granted.

Confidentiality will be ensured as only the researcher and supervisors will have access to the raw data. Patient anonymity will be protected as a list of patient name, hospital number and study number will be generated and this will be filed separately. Only the study number will appear on the Excel spreadsheet to be analysed.

Data captured for cases performed for the period 1 January 2016 up to and including 31 December 2017 will be extracted and an Excel spreadsheet will be created. Date of surgery will be used solely for data extraction purposes and will not be recorded.

Data will be stored securely on a password protected Microsoft Excel spreadsheet for six years after completion of study.

The study will be conducted according to the principles of the Declaration of Helsinki (34) and the South African Guidelines for Good Clinical Practice (35).

4.6 Research methodology

4.6.1 Research design

A retrospective, contextual, descriptive research design will be followed in this study.

A retrospective study dictates a two-dimensional, temporal enquiry between variables, whereby the dependant variable is observed in the present and an attempt is made to link it to an independent variable or event that has already come to pass (36). This study is describing the profile of neurosurgical patients from January 2016 to December 2017.

In a contextual study, a specific study population or sample group of individuals is brought under scrutiny. Such is referred to as a "small-scale world" (37). This study is contextual as it is analysing a specific sub-group of patients presenting to CMJAH.

Descriptive design delineates that the variables under scrutiny are described as they appear. This extends to a description of intervariable relationships but excludes attempts to draw cause-and-effect inferences (38). This study will describe the profile of the neurosurgical cases requiring operative intervention at CMJAH.

4.6.2 Study population

The study population consists of data of patients presenting for neurosurgery at CMJAH operating theatres.

4.6.3 Study sample

Sample size

The sample size will be realised by REDCap Neuroanasthesia Database entries meeting study inclusion criterion. Approximately 150 neurosurgical interventions are performed at CMJAH annually.

Sampling method

In this study a consecutive convenient sampling method will be used. Consecutive sampling is a non-probability sampling method seeking to include all accessible participants as part of the derived sample (36). All REDCap Neuroanasthesia data meeting the inclusion criterion will be included in the study sample.

Inclusion and exclusion criteria

The inclusion criterion for this study is a REDCap Neuroanasthesia Database entry for patients presenting to theatre for neurosurgical intervention from January 2016 to December 2017.

The exclusion criterion for this study is inadequately captured database entries.

4.6.4 Data collection

The data will be extracted from the REDCap Neuroanaesthesia Database in a consecutive manner. Should the data be incomplete, data will be retrieved from source documents i.e. admission books, anaesthetic records and NHLS records. The data captured by the database (Appendix 2) includes:

- patient demographics
- pre-operative neurological assessment
- intra-operative anaesthetic management
- post-operative status.

4.6.5 Data analysis

Data will be captured onto Microsoft Excel spreadsheet. Descriptive and inferential statistics will be used to analyse the data. Categorical variables will be described using frequencies and percentages. Continuous variables will be described using means and standard deviations or medians and inter-quartile ranges, depending on the distribution of the data. Comparisons will be done using Chi-square or Fishers Exact tests. A p-value of <0.05 will be considered statistically significant.

4.7 Significance of the study

Provision of value-based quality health care is a current health imperative. Valid frameworks are needed to realise this end. Clinical registries, such as the REDCap Neuroanaesthesia Database, are being ear-marked as instrumental tools to elucidating, developing and validating key metrics to measure the quality of care delivered. Such data not only serves to drive local quality improvement imperatives but is also used for bench marking purposes.

CMJAH is a central hospital and a principal referral centre for large populous drainage areas. A better understanding of its patient population is mandatory for appropriate resource allocation and teaching purposes. On a national platform, the need for dedicated good quality clinical databases has been expressed (33).

4.8 Validity and reliability of the study

Validity broaches the subject of assurance that measured results are reflective of the true results. In tandem, results are deemed reliable if they are repeatable, consistent and dependable (39).

Steps taken to ensure the validity and reliability of this study include:

- using an appropriate study design
- a single researcher engaging with the data
- analysing data with the assistance of a biostatistician.

4.9 Potential limitations

Retrospective studies are limited by the reliance on the quality of information collected. Clinical registries are only as robust as they are adequately completed. There is an inherent risk of loss of data owing to poor data capturing. The contextual nature of the study limits extrapolation of findings to other settings.

4.10 Project outline

4.10.1 Time frame

Activity	Nov 2017	Dec 2017	Jan 2018	Feb 2018	Mar 2018	Apr 2018	May 2018	Jun 2018	Jul 2018	Aug 2018
Proposal										
Proposal submission										
Ethics & Post Grad approval										
National Health Research Committee										
Data collection										
Data analysis										
Draft article										
Submission										

4.10.2 Budget

The Department of Anaesthesiology will bear the cost of printing and paper.

Item	Number	Cost	Total
Printing	2000	R1/page	R2000
Binding	4	R200	R800
Grand Total			R2800

4.11 References

1. Institute of Medicine, Committee on the Quality of Health Care in America. Crossing the quality chasm: A new health system for the 21st Century. National Academy Press; 2001. [Accessed: 26 August 2017] Available at: http://www.nap.edu/catalog/10027.html.

2. Barker FG II. Pursuing excellence in healthcare delivery: American neurosurgery. Clin Neurosurg. 2010;57:60-8.

3. Lau CY. Quality improvement tools and processes. Neurosurg Clin N Am. 2015;26(2):177-87. doi:10.1016/j.nec.2014.11.016

4. Schipmann S, Schwake M, Suero Molina E, Roeder N, Steudel WI, Warneke N, et al. Quality indicators in cranial neurosurgery: Which are presently substantiated? - A systematic review. World Neurosurg. 2017;104:104-12. doi:10.1016/j.wneu.2017.03.111

5. Asher AL, Parker SL, Rolston JD, Selden NR, McGirt MJ. Using clinical registries to improve the quality of neurosurgical care. Neurosurg Clin N Am. 2015;26(2):253-63. doi:10.1016/j.nec.2014.11.010

6. Vener DF, Pasquali SK, Mossad EB. Anesthesia and databases: Pediatric cardiac disease as a role model. Anesth Analg 2017;124(2):572-81. doi:10.1213/ane.0000000000001448

7. Bradford NK. Interventions to increase the use of electronic health information by healthcare practitioners to improve clinical practice and patient outcomes. Int J EBH. 2016;14(3):136-7. doi:10.1097/xeb.0000000000000074

8. Jacobs JP, Shahian DM, Prager RL, Edwards FH, McDonald D, Han JM, et al. Introduction to the STS National Database Series: Outcomes Analysis, Quality Improvement, and Patient Safety. The Annals of Thoracic Surgery. 2015;100(6):1992-2000. doi:https://doi.org/10.1016/j.athoracsur.2015.10.060

9. Anthony L. Asher, Paul C. McCormick, Nathan R. Selden, Zoher Ghogawala, Matthew J. McGirt. The National Neurosurgery Quality and Outcomes Database and NeuroPoint Alliance: rationale, development, and implementation. Neurosurgical focus. 2013;34(1):E2. doi:10.3171/2012.10.focus12311

10. Day C, Gray A. Health and Related Indicators. 2016. In: South African Health Review 2016 [Internet]. Durban: Health Systems Trust; [243 - 347].

11. Burger R, Ranchod S, Rossouw L, Smith A. Strengthening the measurment of quality of care. 2016. In: South African Health Review [Internet]. Durban: Health Systems Trust; [191 - 200].
12. Lamb JN, Crocker M, Tait MJ, Anthony Bell B, Papadopoulos MC. Delays in treating patients with good grade subarachnoid haemorrhage in London. British Journal of Neurosurgery. 2011;25(2):243-8. doi:10.3109/02688697.2010.544787
13. Chelvarajah R, Lee JK, Chandrasekaran S, Bavetta S. A clinical audit of neurosurgical bed usage. British Journal of Neurosurgery. 2007;21(6):610-3. doi:10.1080/02688690701649488
14. Saikia AK, Sriganesh K, Ranjan M, Claire M, Mittal M, Pandey P. Audit of the Functioning of the Elective Neurosurgical Operation Theater in India: A Prospective Study and Review of Literature. World Neurosurgery. 2015;84(2):345-50. doi:https://doi.org/10.1016/j.wneu.2015.03.031
15. Wang C, Mao Y, Zhu J, Zhou L. The Department of Neurosurgery at Shangai HauShan Hospital. Neurosurgery. 2008;62(4):947-53. doi:10.1227/01.NEU.0000310764.55781.6E
16. Moghavem N, Morrison D, Ratliff JK, Hernandez-Boussard T. Cranial neurosurgical 30-day readmissions by clinical indication. Journal of Neurosurgery. 2015;123(1):189-97. doi:10.3171/2014.12.jns14447
17. Hagan KB, Bhavsar S, Raza SM, Arnold B, Arunkumar R, Dang A, et al. Enhanced recovery after surgery for oncological craniotomies. Journal of Clinical Neuroscience. 2016;24:10-6. doi:http://dx.doi.org/10.1016/j.jocn.2015.08.013
18. Ursalan A. Khan, Amar Bhavsar, Asif H, Konstantina Karabatsou, James R. S. Leggate, Ajit Sofat, et al. Treatment by specialist surgical neurooncologists improves survival times for patients with malignant glioma. Journal of Neurosurgery. 2015;122(2):297-302. doi:10.3171/2014.10.jns132057
19. Nadarajah R, Tait M, Patel P, Ticehurst F, Amin A, Aldlyami E, et al. Audit of Neurosurgery Senior House Officer training in the United Kingdom and Eire: a postal survey. British Journal of Neurosurgery. 2004;18(3):223-6. doi:10.1080/02688690410001732634
20. Attebery JE, Mayegga E, Louis RG, Chard R, Kinasha A, Ellegala DB. Initial Audit of a Basic and Emergency Neurosurgical Training Program in Rural Tanzania. World Neurosurgery.73(4):290-5. doi:10.1016/j.wneu.2010.02.008

21. Kaptigau WM, Rosenfeld JV, Kevau I, Watters DA. The Establishment and Development of Neurosurgery Services in Papua New Guinea. World journal of surgery. 2016;40(2):251-7. doi:10.1007/s00268-015-3268-1
22. Abou-Abbass H, Bahmad H, Ghandour H, Fares J, Wazzi-Mkahal R, Yacoub B, et al. Epidemiology and clinical characteristics of traumatic brain injury in Lebanon: A systematic review. Medicine. 2016;95(47):e5342. doi:10.1097/MD.0000000000005342
23. Tran TM, Fuller AT, Kiryabwire J, Mukasa J, Muhumuza M, Ssenyojo H, et al. Distribution and characteristics of severe traumatic brain injury at Mulago National Referral Hospital in Uganda. World Neurosurg. 2015;83(3):269-77. doi:https://doi.org/10.1016/j.wneu.2014.12.028
24. Boniface R, Lugazia ER, Ntungi AM, Kiloloma O. Management and outcome of traumatic brain injury patients at Muhimbili Orthopaedic Institute Dar es Salaam, Tanzania. Pan Afr Med J. 2017;26:140-6. doi:doi:10.11604/pamj.2017.26.140.10345
25. Adigun TA, Akinyemi OA, Amanorboadu SD, Adeleye AO, Shokunbi MT. An audit of anaesthesia for paediatric neurosurgical procedures in Ibadan, Nigeria. African Journal of Anaesthsia and Intensive Care. 2014;14(1):12-6.
26. Abebe MM, T.; Lends, G.; Bekele, A. Pattern of neurosurgical procedures in Ethiopia. Experience from two major neurosurgical centres in Addis Ababa. East and Central African Journal of Surgery. 2011;16:104 - 10.
27. Bradshaw D, Nannan N, Laubscher R, Groenewald P, Joubert J, Nojilana B, et al. South African National Burden of Disease Study 2000. Estimates of provincial mortality: Summary report. Medical Research Council; 2006. [Accessed: 12 September 2017] Available at: https://www.samrc.ac.za/sites/default/files/files/2017-07-03/estimate.pdf.
28. Nell V, Brown DSO. Epidemiology of traumatic brain injury in Johannesburg—II. Morbidity, mortality and etiology. Soc Sci Med. 1991;33(3):289-96. doi:10.1016/0277-9536(91)90363-H
29. Schrieff LE, Thomas KGF, Dollman AK, Rohlwink UK, Figaji AA. Demographic profile of severe traumatic brain injury admissions to Red Cross War Memorial Children's Hospital, 2006 - 2011 : Research. S Afr Med J. 2013;103(9):616-20. doi:10.7196/SAMJ.7137

30. Allopi K, Padayachee L. An audit of the perioperative anaesthetic management of ventriculoperitoneal shunt insertion in the paediatric population at Inkosi Albert Luthuli Central Hospital. S Afr J Anaesth Analg. 2014;20(5):209-13. doi:10.1080/22201181.2014.979635

31. National Planning Commission. National Development Plan 2030. Our future: make it work. Pretoria: 2012 [Accessed 25 August 2017]. Available at: http://www..poa.gov.za/news/Documents/NPC%20National%20Development%20Plan%20Vision%202030%20-lo-res.pdf.

32. National Department of Health, Republic of South Africa. National Health Insurance for South Africa: Towards universal health coverage. Pretoria: 2017 [Accessed 29 November 2017]. Available at: www.health.gov.za/index.php/nhi?download=2257:white-paper-nhi-2017.

33. Naidoo D. Traumatic brain injury: The South African landscape. S Afr Med J. 2013;103(9). doi:10.7196/SAMJ.7325

34. World Medical Association. Declaration of Helsinki - Ethical principles for medical research involving human subjects. Brazil: World Medical Association; 2013.

35. Department of Health. Guidelines for good practice in the conduct of clinical trials with human participants in South Africa. Pretoria: Government of South Africa; 2006.

36. Brink H, Van der Walt C, Van Rensburg G. Fundamentals in research methodology for health care professionals. Third Edition ed. Cape Town: Juta & Company Ltd; 2012.

37. De Vos A, Strydom H, Fouche C, M. P, Schurink E, Schurink W. Research at grass roots. Pretoria: Van Schaick Publishers; 1998.

38. Burns N, Grove S. The practice of nursing research. Missouri: Saunders Elsevier; 2009.

39. Botma Y, Greeff M, Mulaudzi M, Wright S. Research in Health Sciences. Pretoria: Pearson Education Ltd; 2010.

4.11 Appendices

Appendix 1: Approvals

30 November 2017

Prof Peter Cleaton-Jones,

Chairman,

Wits Human Research Ethics Committee (Medical).

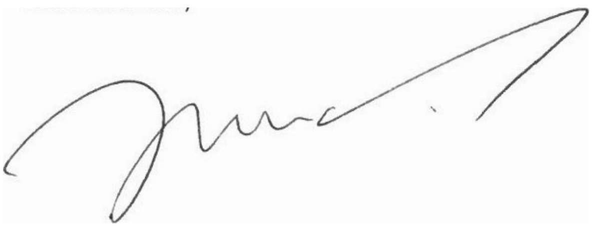
Dear Prof Cleaton-jones,

Re: Request for permission to access Neuroanaesthesia Redcap Database.

The purpose of this letter is to grant Dr Laura Indiveri permission to access the Neuroanaesthesia Redcap Database for the purpose of the research project titled: "A survey of adult patients requiring neurosurgery at a central hospital". This permission is valid for three years from the date of this letter and is subject to all the conditions set by the Wits Human Research Ethics Committee (Medical) and all the necessary approvals from the various authorities.

With kind regards

Yours sincerely



Dr Alastair W. Moodley

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DEPARTMENT OF ANAESTHESIA
Charlotte Maxeke Johannesburg Academic Hospital
University of the Witwatersrand
Tel: 011 488 4344
Fax: 011 488 4343

30 November 2017

Dr Laura Indiveri
Registrar: Department of Anaesthesiology
University of the Witwatersrand

Dear Dr Indiveri

RE: PERMISSION TO COLLECT DATA FOR MMED STUDY

Your request for permission to collect data for an M Med study refers.
Approval is granted to collect data for your study titled: "A survey of adult patients requiring neurosurgery at a central hospital". This approval is subject to gaining the necessary clearances, e.g. ethical, etc.
I am looking forward to the results of your study.

Yours sincerely,

Prof EE Oosthuizen
Clinical Head: Department of Anaesthesia
Charlotte Maxeke Johannesburg Academic Hospital

health and
social development
Department: Health and Social Development
GAUTENG PROVINCE

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL.
Department of Anaesthesia.

Section: Neurosurgical ICU and High Care Unit

To: Research Protocols Committee
University of the Witwatersrand

Dear Chair and Members of the Research Committee, Re: Research plans, Dr Laura Indiveri.

Dr Laura Indiveri has requested permission to review the clinical records of patients admitted to the Neurosurgical ICU and High Care Units.

Dr Indiveri's intention is to obtain information regarding patient demographics, admission diagnoses, clinical course, and outcome of care including that of morbidity and mortality for the purpose of research.

I have no objection to Dr Indiveri undertaking a review of the records of patients admitted to the Neurosurgical ICU and High Care Units for the purpose of the intended research.

Yours faithfully

Colin Clinton MBBCH, FFA(SA)(Critical Care)

Colin Clinton MBBCH,
Consultant Intensivist,
Neurosurgical ICU and Department of Anaesthesia
Charlotte Maxeke Johannesburg Academic Hospital

011 488 4343

Appendix 2: Neuroanasthesia database data collection sheet

Age	______________________________
Gender	◯ Female ◯ Male
ASA	◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5
Elective or emergency	◯ Elective ◯ Emergency
Is this a repeat procedure during this patient's current admission?	◯ Yes ◯ No
Type of neurosurgical procedure	◯ Cranial ◯ Spinal
Type of cranial procedure	◯ Supratentorial craniotomy ◯ Infratentorial craniotomy ◯ Cranioplasty ◯ Transphenoidal ◯ EVD ◯ VP Shunt ◯ Endoscopic 3rd Ventriculostomy
Type of Spinal procedure	◯ Cervical ◯ Thoracic ◯ Lumbar ◯ Myelo/meningocoele
Most likely pathology	◯ Congenital ◯ Tumour ◯ Infective ◯ Vascular ◯ Trauma
Neurosurgical consultant	______________________________
Neurosurgical registrar/ medical officer	______________________________
Anaesthesia consultant	______________________________
Anaesthesia registrar/ medical officer	______________________________
Surgery start time	______________________________
Surgery end time	______________________________
Anaesthetic start time	______________________________
Anaesthetic end time	______________________________

NEUROLOGICAL ASSESSMENT

Glasgow Coma Scale

◯ 1
◯ 2
◯ 3
◯ 4
◯ 5
◯ 6
◯ 7
◯ 8
◯ 9
◯ 10
◯ 11
◯ 12
◯ 13
◯ 14
◯ 15
(If patient intubated, what is the score out of 10?)

Motor Deficit

☐ Right Upper Limb
☐ Left Upper Limb
☐ Right Lower Limb
☐ Left Lower Limb
☐ None

Sensory Deficit

☐ Right Upper Limb
☐ Left Upper Limb
☐ Right Lower Limb
☐ Left Lower Limb
☐ None

Cranial Nerve Palsy

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11 ☐ 12 ☐ None

Pupils equal ? ◯ Yes ◯ No

Speech deficit eg. aphasia, dysphasia

◯ Yes
◯ No

PRESENTING SYMPTOMS (even if they have resolved by the time of anaesthetic assessment)

Headache ◯ Yes ◯ No

Nausea/Vomiting ◯ Yes ◯ No

Seizures ◯ Yes ◯ No

CO-MORBIDITIES

CARDIOVASCULAR

☐ Hypertension
☐ Valvular heart disease
☐ Prev/current CCF
☐ Hypotension (systolic < 90 mmHg)
☐ Arrythmia (including Atrial Fibrillation)
☐ Coronary artery disease
☐ Other
☐ None

RESPIRATORY	☐ Asthma ☐ COPD ☐ Pneumonia ☐ Restrictive lung disease ☐ Smoker ☐ Other ☐ None
ENDOCRINE	☐ Diabetes mellitus ☐ HypERthyroidism ☐ Cushings Syndrome ☐ HypOthyroidism ☐ Adrenal insufficiency ☐ Acromegaly ☐ Diabetes INSIPDUS ☐ SIADH ☐ Other ☐ None
RENAL	☐ Acute kidney injury ☐ Chronic renal failure ☐ Other ☐ None
KNOWN LIVER DYSFUNCTION	◯ Yes ◯ No
HIV STATUS	◯ Positive ◯ Negative ◯ Unknown

INVESTIGATIONS

Haemoglobin g/dl	________________
White cell count (___x10^9 cells/L)	________________
Platelet count (___ x10^9 cells/L)	________________
INR	________________
Sodium	________________
Potassium	________________
Chloride	________________
CO2	________________
Urea	________________
Creatinine	________________
Glucose	________________
CT / MRI Scan	☐ Mass ☐ Hydrocephalus ☐ Cerebral oedema ☐ Midline shift ☐ Obliteration of basal cisterns ☐ Effacement of ventricles ☐ Subarachnoid haemorrhage ☐ Extradural haemorrhage ☐ Subdural haemorrhage ☐ Other ☐ Scan not seen

ECG

- ☐ Normal ECG
- ☐ AF
- ☐ Atrial ectopics
- ☐ Ventricular ectopics
- ☐ LVH
- ☐ LBBB
- ☐ RBBB
- ☐ T wave abnormal
- ☐ Tachy>100
- ☐ Brady< 60
- ☐ ST elevation 1mm or more
- ☐ ST depression 1mm or more
- ☐ Non-specific ST changes
- ☐ Prolonged QT > 410 ms/Shortened QT
- ☐ widened QRS > 100ms
- ☐ ECG not seen

Chest X-Ray

- ☐ no abnormalities
- ☐ hyperinflation
- ☐ mass
- ☐ opacities or infiltrates
- ☐ effusion
- ☐ pneumothorax
- ☐ cardiomegaly
- ☐ bone pathology
- ☐ CXR not seen

INTRAOPERATIVE

Monitors

- ☐ Standard ASA monitors (ECG, sats, NIBP, ETCO2)
- ☐ Asleep arterial line
- ☐ Awake arterial line
- ☐ CVP
- ☐ Ultrasound used
- ☐ Cardiac output monitor
- ☐ Evoked potentials
- ☐ Other

AIRWAY

Easy airway ?
- ◯ Yes
- ◯ No
- ◯ ETT already in situ

Mallampatti
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4

Number of attempts to intubate
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ >3

Airway adjuncts used :
- ☐ None
- ☐ Introducer
- ☐ Bougie
- ☐ LMA
- ☐ Fibreoptic bronchoscope
- ☐ Videolaryngoscope
- ☐ Other

ANAESTHETIC MANAGEMENT

Induction
- ◯ Intravenous
- ◯ Inhalational
- ◯ Combination

Maintenance
- ◯ Sevoflurane
- ◯ Isoflurane
- ◯ Desflurane
- ◯ Propofol + Volatile
- ◯ Propofol TIVA

Opioids

☐ Morphine ☐ Fentanyl ☐ Sufentanil ☐ Alfentanil (Rapifen) ☐ Remifentanil

Dexmedetomidine (Precedex) ◯ Yes ◯ No

Inotropes or vasopressors used :
- ☐ Phenylephrine infusion
- ☐ Adrenaline infusion
- ☐ Phenyl boluses as required
- ☐ Ephedrine boluses as required
- ☐ Adrenaline boluses as required
- ☐ Other
- ☐ None

Mannitol 20% (mls) ______________________________

Dexamethasone ◯ Yes ◯ No

Anticonvulsants given introperatively :
- ☐ None
- ☐ Phenytoin (Epanutin)
- ☐ Valproate (Epilim)
- ☐ Other

Antiemetics
- ☐ None
- ☐ Metaclopromide
- ☐ 5 HT3 antagonists (ondansetron, granisetron)
- ☐ prochlorperazine (Stemetil)
- ☐ droperidol (Inapsin)

Antihypertensives used intra/postoperatively
- ☐ None
- ☐ Labetalol
- ☐ Brevibloc (esmolol)
- ☐ TNT
- ☐ Other

SURGICAL FACTORS

Brain relaxation score
- ◯ Completely relaxed
- ◯ Satisfactorily relaxed
- ◯ Firm
- ◯ Bulging

(Ask surgeon to assess upon opening)

Estimated blood loss (mls) ______________________________

Number of units of Packed Red Cells ______________________________

Number of units of FFP ______________________________

Number of mega units platlets ______________________________

Temperature at skin closure ______________________________

Urine output (mls) ______________________________

POSTOPERATIVE

Extubated in theatre ?

- ◯ Yes
- ◯ No

If not extubated, what was the reason for non-extubation ?

- ◯ 1. Preoperative altered consciousness
- ◯ 2. Hypertension (SBP >160 mmHg)
- ◯ 3. Large tumour resection with midline shift
- ◯ 4. Hypotension±hypovolemia
- ◯ 5. Long surgery (>6 h)
- ◯ 6. Haematocrit < 25%
- ◯ 7. Intraoperative brain swelling
- ◯ 8. Acidosis
- ◯ 9. Hypoxia or hypercapnia
- ◯ 10. Injury to cranial nerves (IX, X, XII)
- ◯ 11. Ineffective spontaneous ventilation
- ◯ 12. Convulsions during emergence
- ◯ 13. Hypoosmolality (5280 mOsmol/kg)
- ◯ 14. Disorders of coagulation
- ◯ 15. Residual neuromuscular blockade

Did the patient have any new neurological deficit or worsening of deficits ?

- ◯ Yes
- ◯ No

Post operatively the patient was sent to :

- ◯ ward
- ◯ high care
- ◯ ICU
- ◯ Other

Outcome

- ◯ Discharged
- ◯ Demised

If discharged, please indicate

Discharge disposition

- ◯ Home
- ◯ Rehabilitation centre
- ◯ Permanent Care Facility
- ◯ Other
- ◯ Unknown

Section 5: Annexures

5.1 Ethics approval

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

R14/49 Dr Laura Indiveri

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180130

NAME: **(Principal Investigator)**	Dr Laura Indiveri
DEPARTMENT:	Anaesthesiology Charlotte Maxeke Johannesburg Academic Hospital
PROJECT TITLE:	A survey of adult patients requiring neurosurgery at a central hospital
DATE CONSIDERED:	26/01/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Helen Perrie and Juan Scribante
APPROVED BY:	Prof C Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	02/07/2018

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in January and will therefore be due in the month of January each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

5.2 Graduate Studies Committee approval

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Private Bag 3 Wits, 2050
Fax: 027117172119
Tel: 02711 7172076

Reference: Mrs Sandra Benn
E-mail: sandra.benn@wits.ac.za

26 April 2018
Person No: 0401539N
PAG

Dr L Indiveri
25 Leeds Road
Ferryvale
1491
South Africa

Dear Dr Indiveri

Master of Medicine: Approval of Title

We have pleasure in advising that your proposal entitled ***A survey of adult patients requiring neurosurgery at a central hospital*** has been approved. Please note that any amendments to this title have to be endorsed by the Faculty's higher degrees committee and formally approved.

Yours sincerely

Mrs Sandra Benn
Faculty Registrar
Faculty of Health Sciences

5.3 CEO approval

<u>GAUTENG PROVINCE</u>

HEALTH REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:

Ms. N. Mzila

Office of the Clinical Director

Email:Nolwazi.Mzila@)gauteng.gov.za

Tell:)11): 488-4812

20 March 2018

Dear Dr. L. Indiveri

STUDY TITTLE: A Survey of Adult Patients Requiring Neurosurgery at a Central Hospital

Permission to conduct the above mentioned study is provisional approved. Your study can only commence once Ethics approval is obtained. Please forward a copy of your Ethics Clearance Certificate as soon as the study is approved by the Ethics Committee for the CEO's office to give you the final approval to conduct the study.

Supported / ~~**not supported**~~

pp

Dr. M.I. Mofokeng
Clinical Director
DATE: 22/03/2C

2 61K

5.4 Turnitin report

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

31st March, 2021

The Chairperson
Graduate Studies Committee
Faculty of Health Sciences
University of the Witwatersrand

Dear Madam,

Re: M Med: **A survey of adult patients requiring neurosurgery at a central hospital**

Dr Laura Indiveri, student number: 0401539N, has submitted her research report to Turnitin which revealed a similarity index of 15%. These similarities appear not to be plagiarism but mainly the use of common terminology and phrases specific to the topic of the research.

Yours sincerely,

H CPerrie

Helen Perrie
Supervisor

1

0401539n:Research_report_v1.docx

ORIGINALITY REPORT

15%	10%	12%	2%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Jeffrey J. Pasternak. "Neuroanesthesiology Update", Journal of Neurosurgical Anesthesiology, 2019 Publication	2%
2	www.health-e.org.za Internet Source	1%
3	Pasternak, Jeffrey J., and William L. Lanier. "Neuroanesthesiology Update :", Journal of Neurosurgical Anesthesiology, 2015. Publication	1%
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"ESICM LIVES 2018", Intensive Care Medicine