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Research

An audit of the perioperative anaesthetic management of ventriculoperitoneal shunt insertion in the paediatric population at Inkosi Albert Luthuli Central Hospital

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Abstract:

Objective: Our study included an assessment of current anaesthetic practice in paediatric ventriculoperitoneal shunt insertion (VPSI), a review of shunt revision and complication rates, an evaluation of the incidence of congenital syndromes, retroviral disease and tuberculosis meningitis, and differentiation with regard to the age groups in which shunt surgery most commonly occurs.

Method: This is was a retrospective audit study. We reviewed information obtained from the computerised database on children from birth to 18 years of age undergoing VPSI at Inkosi Albert Luthuli Central Hospital from 1 September 2012 to 1 September 2013.

Results: One hundred and ten children were included in the study. Arnold-Chiari II and Dandy-Walker syndrome were associated with 8 (7.3%) and 9 (8.2%) of the children, respectively. Tuberculosis meningitis was documented in 21 (19.1%) of the cases. The majority of the anaesthetic techniques included a volatile induction and maintenance of anaesthesia (VIMA) approach, with opioid-sparing practice. Laryngoscopy was not difficult and most of the children were extubated. Half of the shunt insertions were performed in infancy. One fourth of the children required shunt revisions within three months, and these were mostly blocked shunts.

Conclusion: The anaesthetist needs to be cognisant of differences in the anatomy and physiology in these patients, and to have an awareness of associated syndromes and co-morbidities. A VIMA approach seems to be appropriate and the anaesthetist must be prepared to manage the infant age group, together with complications that result in revision surgery.

Keywords: hydrocephalus, paediatric, anaesthesia, ventriculoperitoneal shunt, congenital syndromes, shunt revision

Introduction

Paediatric neuroanaesthesia presents unique challenges to anaesthetists because of differences in anatomy and physiology at various stages of growth and development.[1] The anaesthetist must be fully cognisant of these differences in order to conduct a safe and effective anaesthetic plan. Preoperatively, it is essential to exclude any coexisting diseases and congenital abnormalities, including heart defects. These children may have craniofacial abnormalities and reactive airway disease that may complicate perioperative care. Controversy surrounds the use of sedative premedication as it can affect the evaluation of neurological status, and anaesthetic drug metabolism can be substantially altered by anticonvulsant therapy.[2–4]

A common technique practiced for general anaesthesia is the use of inhalational induction with sevoflurane and oxygen, followed by a non-depolarising muscle relaxant if required, depending on the age of the patient and the duration of surgery. The literature is contradictory as some centres avoid the inhalational induction because of dilation of the cerebral vessels which increases intracranial pressure (ICP), thus a modified rapid sequence is preferred.[5] The choice of maintenance of neurosurgical procedures does not affect the outcome.[6] The use of ketamine in patients with increased ICP is often avoided as it is widely stated that it increases ICP. There is not much evidence regarding this adverse effect at subanaesthetic doses. In a prospective controlled clinical trial of data obtained in a paediatric intensive care unit involving 30 patients with raised ICP (> 18 mmHg), Gad Bar Joseph et al concluded that there was a 30% decrease in ICP after 1 mg/kg ketamine administration (from 25 ± 8.4 to 18 ± 8.5 mmHg)($p < 0.001$) and cerebral perfusion pressure increased from 54.4 ± 11.7 to 58.3 ± 13.4 mmHg ($p < 0.005$).[7] The indication for extubation depends on the clinical scenario. Postoperative monitoring should assess haemodynamic status, respiratory depression, nausea, vomiting and neurological status. Children with Arnold-Chiari malformations may be prone to respiratory depression.[8] An extended recovery room stay may be necessary if complications arise.

The incidence of hydrocephalus in Africa in estimated to be 1–3 per 1 000 live births.[9] The causes of hydrocephalus can be congenital, such as stenosis of the aqueduct of Sylvius, myelomeningocele and Dandy-Walker syndrome, or acquired from intraventricular haemorrhage, space-occupying lesions or infections. The lesion may be communicating (an overproduction or decreased absorption of the cerebrospinal fluid) or non-communicating in type (an obstruction to the flow of cerebrospinal fluid). Vomiting, dehydration, neurogenic pulmonary oedema and coma are signs of impending catastrophe from increased ICP. Imminent decompression is required to prevent brainstem herniation, respiratory and cardiac arrest, and possibly death.[10] Computed tomography may reveal hydrocephalus, cerebral oedema or mass lesions, and is mandatory when any suspicion of an acute neurological process exists.[10] Magnetic resonance imaging may reveal dilated ventricles or the presence of a mass lesion.

Over the years, there has been a slow development in the surgical management of hydrocephalus. The use of ventricular shunts gathered momentum from the early 1950s onward and revolutionised hydrocephalus treatment. Disappointing observations were made with respect to 153 children with hydrocephalus, seen from 1961-1970 in Harare, Zimbabwe. Shunts were inserted into 123, 20% survived and 63% died (17% were not traced), and the surgeons concluded that there was no evidence that surgery was of statistically significant benefit.[11] The electronic equipment was more impressive in Zimbabwe in the mid-1990s, as was the local design of a cheap and effective valve for hydrocephalus.[8] Currently, the insertion of cerebrospinal fluid shunts is the standard treatment for hydrocephalus, but this is prone to complications, with 16% of shunts requiring revision within one month of insertion.[12] Complications include infection, obstruction, haematoma, valve malfunction, disconnection, overdrainage, an outgrown shunt, shunt fracture, an allergic reaction to the material and seizures. There were 44 shunt complications in a prospective study on 40 children who required 48 shunt revisions. Four fifths occurred within six months of the previous surgery.[13] It was reported in a multicentre study that 20.2%, 7.5% and 6.9% of 7 399 patients required one, two, or three or more shunt revisions, respectively. Shunt survival rates were lower with each subsequent shunt revision.[14] A younger age is associated with increased hazard of infection and subsequent cerebrospinal fluid shunt revision significantly increases infection risk.[15] The incidence of early shunt obstruction is high. Later failures are seen less frequently. On average, deaths occur two years after the last shunt revision.[16] A review of the outcomes of 574 patients from an experienced institution in Kenya concluded that there was an overall mortality of 7.1%.[17]

Method

Inkosi Albert Luthuli Central Hospital is a central and a tertiary care, referral hospital, located in Durban, KwaZulu-Natal. The Department of Neurosurgery was commissioned on 5 December 2002 and is the largest neurosurgical unit in southern Africa.[17] It is the sole public sector neurosurgical service that provides consultative services to more than 12 million people in the whole of KwaZulu-Natal, Eastern Cape (Umtata) and possibly parts of southern Mozambique.[17] A significant proportion of paediatric patients present to this department with hydrocephalus requiring ventriculoperitoneal shunt insertion (VPSI). An evaluation of this population group is relevant with regard to performed anaesthetic techniques, associated syndromes and co-morbidities occurring with hydrocephalus, including shunt complications and the age groups that are most commonly encountered.

This was a retrospective clinical audit. The study population included children from birth to 18 years of age undergoing VPSI at Inkosi Albert Luthuli Hospital KwaZulu-Natal from 1 September 2012 to 1 September 2013. Both elective and emergency cases were included. Data were collected from the computer system records and imported into a Microsoft® Excel® audit sheet. Categories included demographic details, co-morbidities, associated syndromes, American Society of Anesthesiologists (ASA) grade, premedication, intraoperative anaesthetic technique, postoperative care, shunt revision in three months and shunt complications. The presence of confirmed retroviral disease and/or tuberculosis meningitis in patients with hydrocephalus was documented. Age groups were divided into < 1 year, 1–3 years, 4–6 years, 7–12 years and 13–18 years, in order to evaluate in which age group shunt surgery occurs most commonly.

Ethics approval

The study was approved by the Biomedical Research Ethics Committee of the University of KwaZulu-Natal (REF BE 140/13).

Results

A total of 110 patients were eligible for inclusion into the study, consisting of 53 females (48.2%) and 57 males (51.8%). The clinical and demographic characteristics are shown in Table 1. Half (50.9%) of the VPSI occurred in the infant group, and there was decreasing occurrence with increasing age. Arnold-Chiari II and Dandy-Walker syndrome was associated with 8 (7.3%) and 9 (8.2%) of the children, respectively. Tuberculosis meningitis was documented in 21 (19.1%) of the cases. Retroviral disease was confirmed in one child, although the retroviral status was not documented in the majority of cases affecting statistical significance. However, those who were exposed, underwent PCR testing. The results were negative.

The perioperative anaesthetic management is outlined in Table 2. With regard to premedication, 3 (2.7%) of the children received sedation in the form of an antihistamine (trimeprazine), 7 (6.4%) received antiepileptic drugs (phenytoin) and 7 (6.4%) received paracetamol syrup. The majority of the children were classified as ASA grade II. A volatile induction 104 (94.5%), followed by a volatile maintenance technique 110 (100%), was employed in the majority of cases. Features of increased ICP were not noted. Intravenous induction was performed when an intravenous line was already sited. A rapid sequence induction

Table 1: The clinical and demographic characteristics of children undergoing ventriculoperitoneal shunt insertion at Inkosi Albert Luthuli Central Hospital, KwaZulu-Natal (*n* = 110)

Characteristic	n (%)
Gender	
Male	57 (51.8)
Female	53 (48.2)
Age group (years)	
< 1	56 (50.9)
1–3	29 (26.4)
4–6	15 (13.6)
7–12	9 (8.2)
13–18	1 (0.9)
Syndrome	
Arnold-Chiari II (AQ2)	8 (7.3)
Dandy-Walker	9 (8.2)
Co-morbidity	
Retroviral disease	1 (0.9)
Tuberculosis meningitis	21 (19.1)
Type of surgery	
Emergency	59 (53.6)
Elective	51 (46.4)

occurred in two cases due to a non-fasted state. Minimal problems were encountered regarding difficult intubation as most children (87, 79.1%) had a grade I Cormack-Lehane view.[18] Analgesia involved the use of synthetic boluses of short-acting opioids (fentanyl and rapifen). However, these were limited to 34 (30.9%) of cases. Ketamine and paracetamol provided most of the analgesia requirements. Minimal use of muscle relaxants was identified. Crystalloids were used for most cases in the form of Ringer's lactate and Plasma-Lyte® solutions. Most of the children were extubated and transferred to the ward postoperatively.

The three-month shunt revision rate was calculated as 24.5%, and most shunt complications requiring revision were due to blockage, as shown in Table 3.

Discussion

This review shows that the issues surrounding the perioperative anaesthetic management of VPSI in the paediatric population involves caring for a sick population with associated syndromes, co-morbidities and complications. Approximately one fifth of the patients with hydrocephalus were diagnosed with tuberculosis meningitis. This is not an uncommon phenomenon, as in a prospective cohort study, Tushar et al found that of 80 patients with tuberculosis meningitis, 52 (65%) had hydrocephalus on presentation.[19] In a study on 217 children with tuberculosis meningitis in South Africa, 30% required ventriculoperitoneal shunting for either non-communicating hydrocephalus or failure of medical therapy with diuretics in communicating hydrocephalus.[20] The Dandy-Walker syndrome is a continuum of aberrant development of the posterior fossa. The mean incidence of this syndrome in individuals with hydrocephalus is estimated to be 3%.[21] Arnold-Chiari II malformations involve displacement of the cerebellar vermis into the upper cervical canal, with anomalies in the midbrain, pons and medulla. These children can also present with sleep apnoea.[2] These malformations are encountered relatively commonly, with an incidence of 1 in 1 000 live births.[22]

Limited literature reviews the anaesthetic management of VPSI specifically, although this is a common and lifesaving procedure. Minimal sedation was used preoperatively for the patients in this study, and when used, it was in the form of an antihistamine because of minimal respiratory depressant effects. Although preoperative sedation alleviates anxiety, which in itself can cause a further increase in ICP, caution is advised with regard to preventing hypoventilation and resulting hypercapnia, with an increase in ICP. Sedative premedication may also mask the signs of neurological dysfunction. The VIMA approach is well documented in the literature regarding paediatric anaesthesia in general, but a concern exists that volatile anaesthetics can cause cerebral vasodilation and cause an increase in ICP. A low concentration of 0.5 minimum alveolar concentration (MAC) or less is recommended in the literature.[1] Our practice uses a high MAC (> 1.5) of sevoflurane during induction without major complications. However, soflurane and sevoflurane appear to have minimal effects on cerebral blood flow and cerebrovascular reactivity to CO_2 in concentrations of 0.5–1.5 MAC.[1] Difficult intravenous access is also reduced by volatile induced vasodilatation. Antibiotic prophylaxis is given 30 minutes prior to surgical incision in the form of a second-generation cephalosporin (cefuroxime). Positioning of the patient is vital

Table 2: The perioperative anaesthetic management of children undergoing ventriculoperitoneal shunt insertion at Inkosi Albert Luthuli Central Hospital, KwaZulu-Natal (n = 110)

Characteristic	N (%)
Premedication	
Sedation	3 (2.7)
Anticonvulsant drugs	7 (6.4)
Analgesia	7 (6.4)
ASA classification	
1	21 (19.1)
2	63 (57.3)
3	22 (20)
4	4 (3.6)
Induction	
Inhalational	104 (94.5)
Intravenous	6 (5.5)
Laryngoscopy grade	
I	87 (79.1)
II	21 (19.1)
III	2 (1.8)
IV	0 (0)
Maintenance	
Inhalation	110 (100)
Intravenous	0 (0)
Analgesia	
Opioids	34 (30.9)
Ketamine	72 (65.5)
Paracetamol	71 (64.5)
Muscle relaxants	
Suxamethonium	2 (1.8)
Non-depolarising muscle relaxants	7 (6.4)
Fluids	
Crystalloids	109 (99.1)
Colloids	1 (0.9)
Postoperative care	
Extubated to ward	107 (97.3)
T-piece	2 (1.8)
Intensive care unit ventilated	1 (0.9)

ASA: American Society of Anaesthesiologists

Table 3: Shunt characteristics

Shunt revision performed within 3 months following VPSI	27 (24.54%)
Shunt complications*	
Blocked	20
Septic	12
Exposed	3
Overdrainage	1
Disconnection	1
Valve malfunction	1

VPSI: ventriculoperitoneal shunt insertion
*: The number of shunt complications includes patients presenting for revision within three months of insertion, and patients requiring revision but who had had their shunts inserted more than three months before the study period

to support the large head, and a folded drape should be placed beneath the shoulders to bring the external auditory meatus in line with the sternum (Figure 1). Although the large head size in hydrocephalus may be associated with a difficult intubation, this technique has been shown to improve the laryngeal view as 87% of the patients were Cormack-Lehane grade I classification. It is also possible to spray the vocal cords with lignocaine. Temperature and glucose monitoring were recorded because of the high risk of hypothermia and hypoglycaemia, respectively, in this age group.

Drug dosing in these patients is also difficult as a large proportion of the body mass derives from the head. Pharmacokinetics are also affected owing to malnutrition, dehydration and obesity. Patients on anticonvulsant therapy require larger doses of muscle relaxants due to induced enzymatic metabolism.[2–4] Our study found that muscle relaxants were used minimally, which is an accepted practice.[23] This may be because of the young age of the anaethestised group, the ability to take over the ventilation and the concerns about postoperative apnoea. The use of muscle relaxants in this age group is operator dependent. Similarly, an opioid-sparing approach was seen because of concerns about respiratory depression in these relatively short cases. The ability to evaluate the neurological status prior to extubation was also confounded. Thus, there was extensive use of non-opioid analgesia in the form of intravenous paracetamol and ketamine. When opioids were used, fentanyl was administered in boluses of 1 ug/kg prior to tunnelling, which is the most painful part of the procedure. Local anaesthetic was also infiltrated to the surgical site by the neurosurgeons and postoperative analgesia supplementation was not required in recovery. The majority of the patients were safely extubated and transferred to the ward with this technique. Analgesia in the ward included paracetamol, as well as tilidine drops. Two patients remained intubated because of a low Glasgow coma scale, and were transferred to the high care ward breathing spontaneously. One patient required intensive care unit admission and ventilation as a result of type 1 respiratory failure from right upper lobe pneumonia.

There has been a gradual decrease in VPSI over the last few years owing to the introduction of advanced technology, including endoscopic third ventriculostomy and endoscopic fenestration. Finally, the problem of shunt revision needs to be emphasised as these children require repeated anaesthetics owing to complications pertaining to the shunt. The complications vary, but blocked shunts are a common occurrence. Shunt designs, such as those with siphon control devices or flow-regulated valves, may alleviate the causes of shunt occlusion.[24] Prospective studies might help to decrease complication rates.

Figure 1: Positioning of the child for the procedure

Limitations

This was a retrospective study which relied on data from attending staff, with possible inaccuracies and loss of data. The children were not followed-up, and there an assessment was not made with regard to outcome. Thus, a prospective follow-up study is warranted.

Conclusion

Hydrocephalus is a significant problem and anaesthesia for the insertion of ventriculoperitoneal shunts requires an understanding of paediatric neurophysiology and the relationship between ICP and cerebral perfusion pressure in both normal and disease states. The anaesthetist must be prepared to provide anaesthesia across the entire paediatric age group. The application of basic anaesthetic principles permits the safe conduct of surgery in this varied and challenging population of children.

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