VARIATIONS IN VENTRICULAR ENDOSCOPIC FINDINGS IN INFANTS WITH HYDROCEPHALUS

Proposal for a dissertation to be submitted as partial fulfilment of the requirements for the award of Master of Medicine degree (MMED) in General Surgery, University of Nairobi

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2011

DECLARATION

I hereby declare that this study is my original work and has not been presented for dissertation at any other university.

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Acknowledgements

I would like to thank my supervisors Mr. D.L. Oluoch – Olunya and Mr. M.M. Qureshi for their patience and guidance through the period of the study. This work would not have been possible without their support.

I am also grateful to Mr. P.K. Wanyoike and Dr. Boore for their tremendous support and contribution.

I would also like to thank my fellow residents in the division of neurosurgery.

LIST OF ABBREVIATIONS

AKUH(N)	Aga Khan University Hospital
CSF	Cerebrospinal Fluid
CT	Computerized Tomography
ERC	Ethics and Research Committee
ETV	Endoscopic Third Ventriculostomy
KNH	Kenyatta National Hospital
MRI	Magnetic Resonance Imaging
NEV	Neuroendoscopic Ventriculoscopy
SPSS	Statistical Package for Social Sciences
VP	Ventriculo peritoneal
UON	University Of Nairobi

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ABSTRACT

Background:

Endoscopic Third Ventriculostomy has become well accepted as a standard treatment option for selected patients with symptomatic obstructive hydrocephalus. It has become established as an alternative to initial ventriculoperitoneal (VP Shunting) and ventriculoatrial shunt implantation and to revision of a failed shunt.

The procedure has a relatively high failure rate in infants. Factors that seem to contribute to ETV failure include the patients age and the aetiology of hydrocephalus. Variant anatomic findings have been sporadically reported and seem to contribute significantly to ETV failure.

This study documented the variant anatomic findings of Third Ventricle encountered in neuroendoscopy.

Objective:

The study aimed to document the variant anatomy of the third ventricle as seen during neuroendoscopy in infants with hydrocephalus.

Materials and Methods:

The study was prospective cross-sectional descriptive studies carried out at the Kenyatta National Hospital (KNH) and The Aga Khan University Hospital (AKUH). Thirty three patients were included in the study.

The patients, who met inclusion criteria, were recruited over a period of 6 months from December 2010 to May 2011. The video recordings of 33 patients who underwent ETV were reviewed.

Using a structured questionnaire data was collected and SPSS 17.0 was used to analyze the data.

Analysis was done by associating occurrence of variant endoscopic findings to: age, sex, aetiology of hydrocephalus and duration of operating time. Charts and tables were used to present the results

Results:

In 27 of the 33 patients, variant endoscopic findings were encountered accounting for an incidence rate of 81.8%. Variant findings were present in the wall of the third ventricle in 27 (81.85%) of infants while variant ventricle floor findings were present in 17 (51.5%) of infants. Sixteen (48.5%) infants had variations in ventricular endoscopic findings affecting both the ventricle wall and floor. ETV was completed in all 6 patients without variant anatomy. Where variant findings occurred, the length of the procedure was prolonged with increasing variability. 2 out of 27 procedures were not completed due to obscured visibility.

Conclusion:

Variant findings in the third ventricle are a frequent finding during ETV in infants and seem to have the potential to increase the difficulty of the operation as is indicated by the increased operating time that occurred with greater variability.

Successful perforation and shorter operation correlated with absence of anatomic variants.

Chapter 1: Introduction

1.1Background

Hydrocephalus is the excessive accumulation of cerebrospinal fluid (CSF) within the cranial vault due to excessive production or inadequate absorption.

The prevalence and incidence of hydrocephalus in developed nations is estimated at 0.9–1.2 per 1000 and 0.2–0.6 per 1000, respectively (1) The incidence in Kenya has not been documented, however, according to extrapolated statistics from the CureResearch group, the projected incidence rate in Kenya is 0.065%.

In East Africa, the aetiology of hydrocephalus in children is 57% post-infectious, 29% non-post-infectious, and 13% myelomeningocele. Thus, neonatal meningitis / ventriculitis are likely the most common cause of hydrocephalus in East Africa (2).

Endoscopic third ventriculostomy (ETV) has become well accepted as a standard treatment option for selected patients with symptomatic obstructive hydrocephalus. It has become established as an alternative to initial ventriculoperitoneal and ventriculoatrial shunt implantation and to revision of a failed shunt (3).

Endoscopic third ventriculostomy provides direct communication between the third ventricle and the interpeduncular and prepontine subarachnoid spaces, thereby by-passing an obstruction at the level of the sylvian aqueduct or the fourth ventricle or its outlets (3).

Anatomic anomalies of the third ventricle have been encountered during ETV. Many of these anomalies have the potential to impair the efficacy of ETV and increase the surgical morbidity (4)

As a CSF diversion procedure, ETV has a high failure rate in children, especially in those aged below one year [5].

Studies in this subset of patients have explained the high failure rate as being due to young age [5, 6, 7]. Other studies have shown that ETV failure is independent of age and is related to aetiology [8, 9].

Studies relating ETV failure to variations in anatomy in infants have not been described. In older patients, ETV failure and surgical complications were noted with variations in anatomy[10].

Variant anatomy may contribute significantly to ETV failure. This study proposes to document the variant anatomy encountered during neuroendoscopy and to record their frequency of occurrence.

1.2Study justification

This study was conducted with the principle objective of describing and documenting the variant endoscopic findings in the Third Ventricle of infants with hydrocephalus. This was desirable since the failure rate following endoscopic third Ventriculostomy (ETV) in infants is relatively high and may be a result of structural variations within the third ventricle.

Studies describing variant structural findings within the third ventricle have been done but none has been done to describe these findings in infants.

Studies based on adult populations have shown that variations in third ventricle anatomy contribute to ETV failure and increase the complications during the procedure[10]. It is likely that variant structural findings of the third ventricle in infants may contribute to the success

or failure rate of ETV in infants. Thus, it is important to document structural findings as seen during neuroendoscopy in this population.

1.3Study utility

The study may determine the occurrence and frequency of variant anatomic findings during neuroendoscopy. The results obtained from this study could form the basis of other related future studies.

1.4 Study Question

What is the incidence of variations in anatomy of the third ventricle found in infants during neuroendoscopy?

1.5 Broad Objective

To describe and document the anatomy of the third ventricle as seen during endoscopy of the third ventricle in children aged one year and below.

1.5.1. Specific objectives

a) To describe the occurrence of variant neuroendoscopic findings of the third ventricle in infants.

b) To correlate operating time & completion of ETV with the findings on neuroendoscopy.

Chapter 2: Literature Review

2.1 Background

The reported success rates following ETV are in the range of 60% to 90% in adults [3].

The success rate is lower in children is lower, especially in children aged below one year with success rates ranging from 37.5% [5] to 64% [6, 7, 8, 9] following ETV for a variety of aetiologies.

The physiological explanation for this age effect is not clear. Possible explanations are that the infant brain, meninges, and cranium cannot tolerate the persistent elevated increased intracranial pressure that occurs after this procedure or that their absorptive system is immature [11].

The evolution theory in cerebrospinal fluid dynamics postulates that the high incidence of failure of ETV in treatment of hydrocephalus in the neonatal and infantile periods may depend on the specific CSF dynamics, in which the major CSF pathway has not developed and the minor pathway plays a significant role in the individual maturation process [12].

Some studies suggest that aetiology is the main determinant of ETV success and that ETV success may be independent of age [13, 14, 15, 16, 17] with success rates of 87% reported for aqueductal stenosis and 27% success rates for hydrocephalus associated with myelomeningocoele.

There seems to be improvement in outcomes with increase in age following ETV. The influence of different cut-off ages on success or failure rates is reflected in several studies e.g. Teo and Jones [8] with ETV success rates of 53% versus 80% in patients less than 2 years versus patients older than 2 years.

Goyareb et al [9] reported an overall ETV success rate of 64% in infants less than one year with 52% success in infants younger than 6 months and 85% success in infants 6 – 12 months old.

Young age is also a risk for CSF shunt failure [19, 20]; therefore, young age may be a risk factor for any CSF diversion procedure.

The reasons for which CSF diversion procedures have a fairly high failure rate in infants have not fully unexplained. It has been observed that children aged above 2 years of age and adults have relatively clear basal cisterns while arachnoid scarring is more predominant in infants and children aged less than 2 years [21].

Wagner et al. advocated that CSF pathway re - closure is the factor most responsible for ETV failure in younger infants. They reported that out of 16 failed ETVs in 11 patients younger than 1 year of age, new arachnoid membranes in the basal cistern blocking CSF flow were found. They advocated that infants have a higher tendency to form new arachnoid membranes than do older patients, and this might be one of the causes of lower success rate of ETV in younger patients [21].

The effect of anatomic anomalies on ETV has been sporadically reported. These anomalies may have a negative impact on the outcome of ETV. While anatomic variants and anomalies have been described in infants, their frequency and potential to complicate or lead to failure of ETV has not been described.

A study at a single centre showed that anatomic variants and anomalies were encountered at 36% of ETV procedures [10]. Anatomic variants contributed to longer duration of surgery, greater incidence of abandoned procedures and higher failure rates following ETV.

Anatomic variants encountered during neuroendoscopy include firm and opaque floor of the third ventricle, declining floor of the third ventricle, small foramen of Monro, narrow third ventricle, agenesis of corpus callosum, divided fornix (10).

The thickness of the third ventricular floor, a variant finding at neuroendoscopy, seems to have a bearing on ETV outcomes, with higher failure rates seen in thicker third ventricle floors (22).

2.2 Endoscopic anatomy

It is essential to be familiar with the ventricular anatomy, especially as seen through the two-dimensional "fish eye" view of the endoscope.

To identify appropriate entry into the ipsilateral ventricle, the head of the caudate, situated laterally, and the septum pellucidum, situated medially, must be identified. The right foramen of Monro, often the first structure visualized, also is essential for orientation.

The septum may be intact, or, as is often the case in chronic obstruction, largely absent, with only residual fibres and vessels.

The superior and anterior arches of the fornix and the caudal choroid plexus are key structures to pass safely when entering the third ventricle.

The choroid plexus of the lateral ventricle projects forward to the foramen. At the posterior rim of the foramen of Monro, the vein of the septum pellucidum, located anteromedially, joins the thalamostriate vein, located posterolaterally. These vessels join and ultimately form the internal cerebral vein.

The fornix is intimately related to the foramen of Monro. Each fornix passes from the medial margin of the foramen along its anterior edge before diving into the medial wall of third ventricle.

The anterior part of each thalamus forms the lateral wall of the third ventricle. The Massa intermedia joins the lateral walls at the midline posteriorly. The posterior part of the third ventricle includes the pineal gland, posterior commissure, and sylvian aqueduct.

The floor of the third ventricle, which is rich with important anatomic landmarks, extends from the optic chiasm anteriorly to the orifice of the sylvian aqueduct posteriorly.

When viewed from inside the third ventricle, the optic chiasm forms a prominence at the anterior margin of the floor.

Looking anteroposteriorly, one sees the optic recess, optic chiasm, infundibulum, infundibular recess, tuber cinereum, and mammillary bodies (3).

2.3 Images

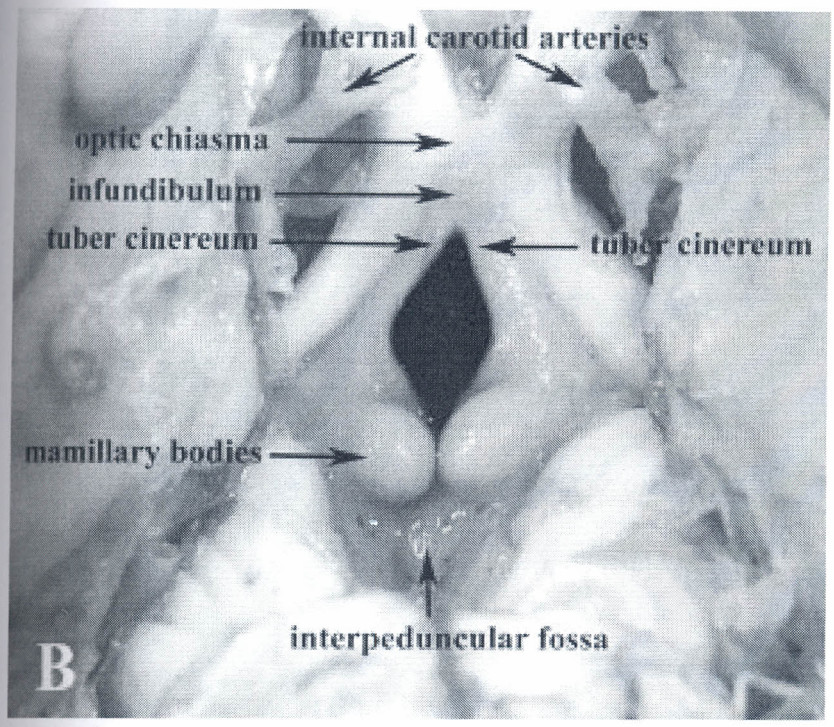


Figure 1: Cadaveric section of the floor of the third ventricle

With permission from Dr. Selcuk Yilmazar

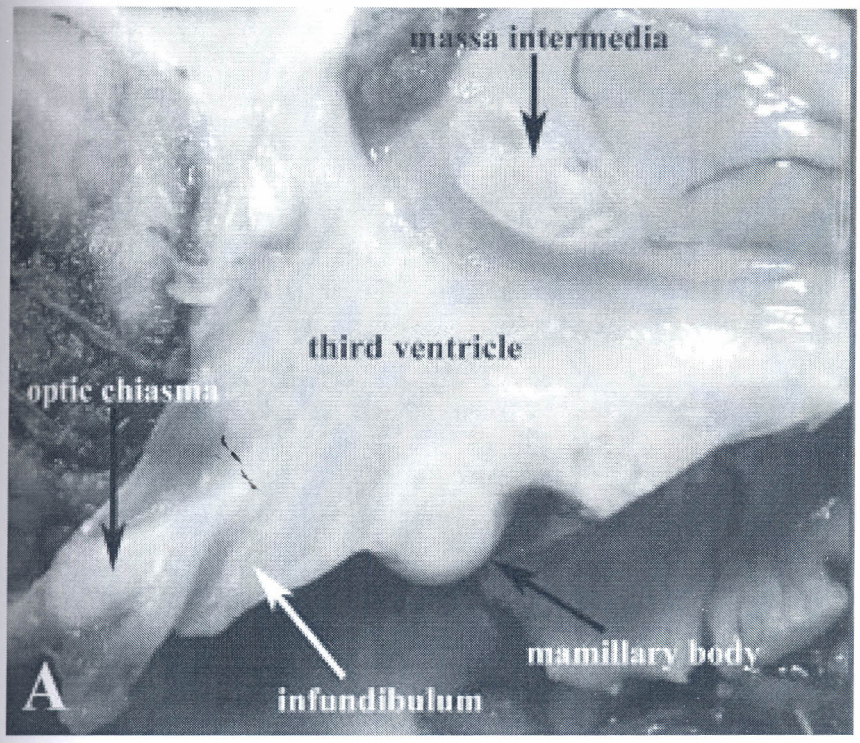


Figure 2: Cadaveric section of the third ventricle wall

With permission from Dr. Selcuk Yilmazar

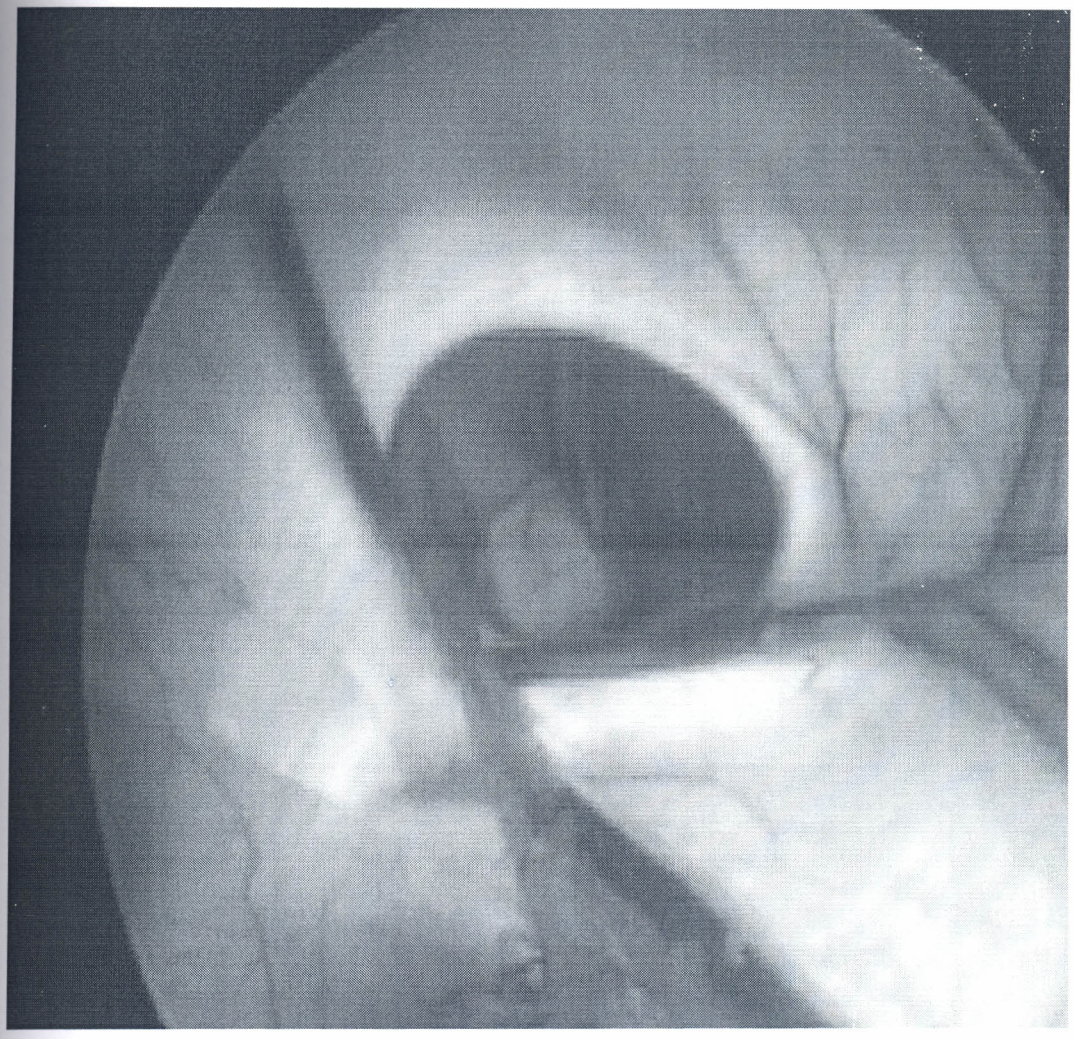


Figure 3: *Endoscopic view of the right foramen of Monro includes the fornix, choroid plexus, head of the caudate, and thalamostriate vein.*

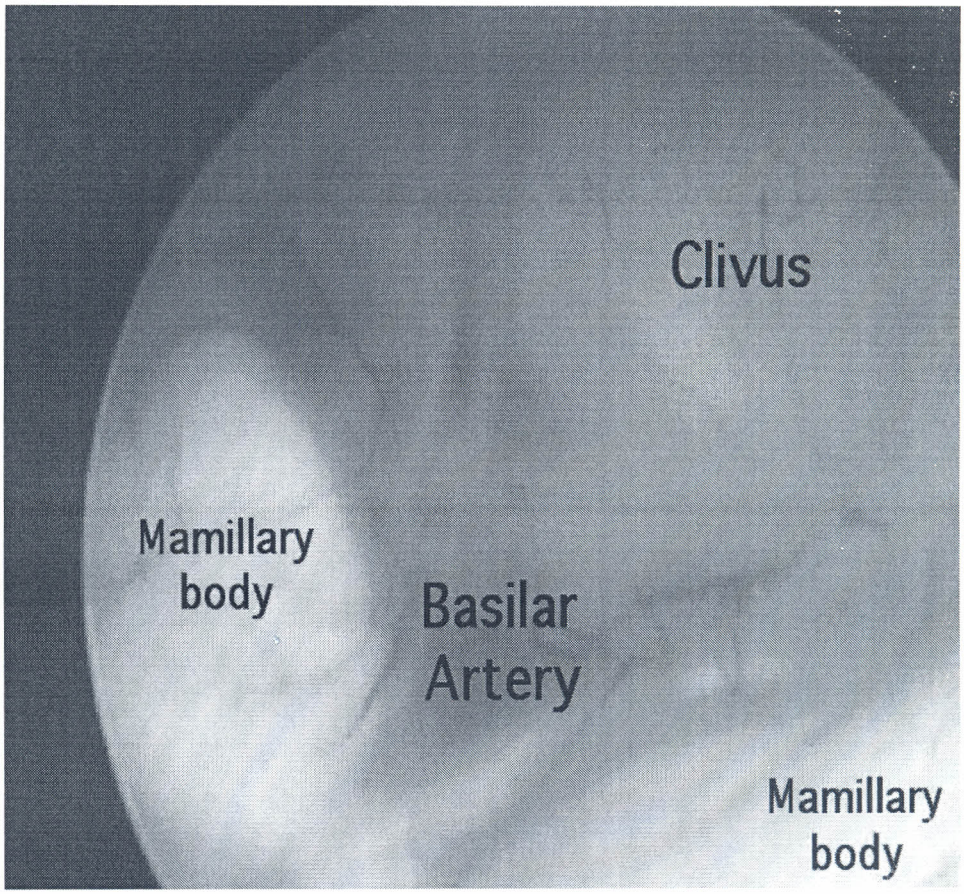


Figure 4: Endoscopic view of the floor of the Third Ventricle

Chapter 3: Methodology

3.1 Study Design

The study was a prospective cross-sectional descriptive study that ran for a duration of 6 months between December 2010 to May 2011.

3.2 Setting

The study was carried out at the Kenyatta National Hospital and the Aga Khan University Hospital Nairobi.

3.3 Inclusion Criteria

1. Children aged one year and below admitted with hydrocephalus and for whom surgical intervention was intended.

2. All patients for whom informed consent was given by parents or legal guardians.

3. Infants with radiological evidence of hydrocephalus as demonstrated by trans - cranial ultrasonography and brain CT scan. These included patients who underwent ETV and those who did not.

3.4 Exclusion Criteria

Patients for whom informed consent was not obtained.

3.5 Methods

- Infants with radiological evidence of hydrocephalus and whose parents or legal guardians gave informed consent for ETV procedure were admitted at KNH and AKUH.
- Data was collected by the principle investigator and the surgeons performing the ETV procedures.
- Each ETV procedure was filmed. Data was then entered into a structured questionnaire (Appendix III).
- The surgical procedure performed was as follows:

Equipment used:

The endoscopic sets included a rigid endoscope, video camera, optical coupler, light source, irrigation set with Normal Saline solution, ventricular cannula (peel-away sheath), monopolar cautery, Fogarty Angiocath balloon, and hand-held video camera recorder.

Surgical Procedure:

Under General Anaesthesia, the patients were placed the supine position with the head held neutral in a doughnut or in pin fixation. The head of the bed was elevated

slightly to allow the entry hole to be at the top, preventing CSF loss from the ventricle and minimizing air entrapment.

The entry point for neuroendoscopy was just anterior to the coronal suture at the mid pupillary line. Once under general anaesthesia and after the patients were positioned, a point 12 cm from the nasion in the midline was marked. Another point 2.5 cm perpendicular to this point was marked and corresponded with the entry point of the endoscope. A curvilinear skin flap was then raised followed by incision of the pericranium & dura mater. The exposed cerebral cortex over the third ventricle was cauterized and the peel away sheath introduced. CSF was collected and sent for microbiology & biochemistry examination.

The entry port was through a 14-Fr peel-away sheath inserted in the right lateral ventricle and fixed in place by small artery forceps on each side. A 0° rigid endoscope was passed via this port into the frontal horn. After confirming the anatomy of the foramen of Monro, the endoscope was carefully be passed into the third ventricle until the floor of the third ventricle was well visualized.

Because instruments passed through the endoscope often enter outside of the visual field, they were extended and seen before entry into the third ventricle to avoid injuring the foraminal structures.

The findings of the lateral ventricle wall as well as the clarity of the CSF were noted prior to passage of the endoscope into the third ventricle. Once visualized, the third ventricle floor was filmed prior to perforation where possible.

A Fogarty catheter was used to perforate the floor of the third ventricle. The site chosen was relatively avascular and lay between the clivus and the basilar artery. Under visualization, the Fogarty catheter was gently rotated against the floor of the third ventricle until it perforated the membranous floor. The newly created communication between the third ventricle and the basal cistern was dilated by inflating the balloon until flapping of the edges of the perforated membrane was noted.

The endoscope was advanced into the basal cistern with care taken not to injure the basilar artery. Any fibrin strands obstructing flow of CSF were gently teased away by inflating the balloon. The endoscope was then removed, haemostasis at the corticotomy site ensured, and pericranium, galea aponeurosis and skin opposed in that order.

The video images of the anatomic findings at neuroendoscopy were also carefully documented on the operation notes.

3.6 Sample size determination

The standard statistical approach to determination of sample size for a prospective descriptive study such as this one requires specification of an estimate of the proportion (prevalence) of failure rate among patients aged below one year exposed to ETV treatment to be estimated; the desired level of confidence desired for the proportion estimate; and a tolerance error margin or width of the confidence interval (a measure precision of the estimate), so that the necessary sample size is then calculable for a given precision level.

The sample size formula below is then used to estimate the sample size.

$$n = \frac{Z^2_{\alpha/2} \times P(1-P)}{d^2}$$

Where:

n = is the required sample size

p = expected prevalence or proportion or estimated proportion of failure among patients aged below one year exposed to ETV treatment. In this study we will use 36% (based on the findings of T. Beems et al. 2002)

d= degree of precision or a tolerance error margin or width of the confidence interval (measured precision of the estimate which ranges from 20%- 1%).

$Z^2_{\alpha/2}$ = Standard normal deviate at 5% level of significance

For a 95% CI, z = 1.96

For this study, we will specify the level of confidence as 95%, an error margin of ±5% as being considered acceptable and based on the past study (T. Beems et al; it is

expected that we will have 49% failure rate among patients below the age of one year exposed to ETV treatment).

Using this information in the sample size formula above, we estimate that the following sample sizes would be necessary to achieve the required sufficient precision for the estimated prevalence of failure among children aged one year and below exposed to ETV treatment.

Therefore:

$Z^2_{\alpha/2} = 1.96$

$P = 0.36$

$1-P = 0.64$

$d = 0.10$

$n = \mathbf{88}$

The formula used above assumes a large or infinite target population size. However, on average two ETV treatments are conducted weekly among the population of children less than one year in the study hospitals, implying that the accessible population during the study period (July 2010 to November 2010) is 52 infants and therefore less than the desired sample size of 88 infants.

Based on the methods proposed by Mugenda (1999) [23] we adjusted the desired sample size considering the accessible population using the following formulae.

$$nf = \frac{n}{1+(\frac{n}{N})}$$

Where: nf = the desired sample size (when population is less than 10,000)

n= the desired sample size (when population is more than 10,000)

N = the estimate of the accessible population size

$$nf = \frac{88}{1+(\frac{88}{52})}$$

nf = 32 infants

Therefore, the effective sample size in this study is **32 infants** exposed to ETV treatment.

3.7 Sampling Procedure

Non probability Convenience Sampling method was used. The sample included all children aged one year and below admitted with hydrocephalus and for whom surgical intervention was intended and who meet all inclusion and none of the exclusion criteria until the desired sample size of 32 was achieved.

All patients meeting the inclusion criteria were consecutively enrolled until the desired sample size was attained.

3.8 Data Presentation and Analysis

DATA MANAGEMENT AND ANALYSIS

Data collection was conducted using structured questionnaires to document patient information, diagnostic and aetiology information and findings of neuroendoscopy. Questionnaire information was coded before entry into an MS Excel spreadsheet. Data cleaning and verification was conducted prior to analysis. During data cleaning the entered values were *checked for plausibility* by conducting range and consistency checks for each variable in the dataset. Any implausible values or inconsistencies identified during data

cleaning were resolved through validation based on the original questionnaires. Data were then transferred to SPSS (version 17) for analysis.

Basic descriptive analysis involving univariate description of each variable in the dataset was conducted using SPSS procedures for calculating means (SD) and medians (ranges) for continuous variables and producing frequency tables and graphs for categorical variables. The aim of the descriptive analysis was to summarize each variable in the dataset and present descriptive statistics including mean (SD) age of infants, and distribution of categorical variables like sex.

The main study outcome was estimated as the percentage of hydrocephalic patients with variations in ventricular endoscopic findings. Chi square test was used to compare percentages of patients with variant findings for categorical variables e.g. infants' sex versus occurrence of variant endoscopic findings. Fischer's exact test was used instead of chi square when the expected cell count was less than five. For continuous variables e.g. patients' age, ANOVA was used to compare means for groups of patients with and without variant endoscopic findings. The findings were presented as tables, and graphs.

3.9 Ethical Considerations

Approval of the study from department of surgery, UON was obtained.

Ethical approval was obtained from KNH Ethics and Research Committee and AKUH Ethics Commitee.

Informed consent was obtained from parent/guardian of the patients. (Appendix I).

3.10 Study Limitations

During the data collection period, the neuroendoscope was accidentally damaged and required to be replaced. The endoscope is costly and had to be imported into the country, delaying data collection by six months.

Chapter 4: Data Analysis and Discussion

Patient recruitment

During the period between December 2011 and May 2011, a total of 33 ETV procedures were carried out. The number of patients per hospital was 4 at AKUH and 29 patients at KNH. The number of procedures conducted by three surgeons ranged from 5 to 20 with a median number of 8 ETV procedures conducted by each surgeon participating in the study.

Prevalence of variations in ventricular findings

Overall, variations in ventricular endoscopic findings were detected among 27 (81.8%) infants with hydrocephalus (Table 1). These variant findings were present in the wall of the third ventricle in 27 (81.85) infants while variant ventricle floor findings were present in 17 (51.5%) infants. Sixteen (48.5%) infants had variations in ventricular endoscopic findings affecting both the ventricle wall and floor.

Table 1: Prevalence of variations in ventricular endoscopic findings in 33 infants with hydrocephalus

Finding	Frequency (n)	Percent
Any variations in ventricular endoscopy		
Absent	6	18.2
Present	27	81.8
Variant ventricle wall findings		
Absent	6	18.2
Present	27	81.8
Variant ventricle floor findings		
Absent	16	48.5
Present	17	51.5

Demographic characteristics

This section describes the findings of an analysis of the basic demographic characteristics of the 32 infants undergoing ETV procedures to treat hydrocephalus in the study.

Patients' age

The age of patients in this study ranged from 2 months to 12 months and the average age of patients was 8 (SD 4) months. Of the 33 patients, 13 (39.4%) were less than 6 months of age.

Comparison of mean age of infants with and those without variation in ventricular endoscopic findings reported in Table 1 showed that variation in ventricular endoscopic findings occurred in slightly older infants but the differences in mean age of infants with and without variations was not statistically significant.

Table 2: Mean age of infants with and without variations in endoscopic ventricular findings

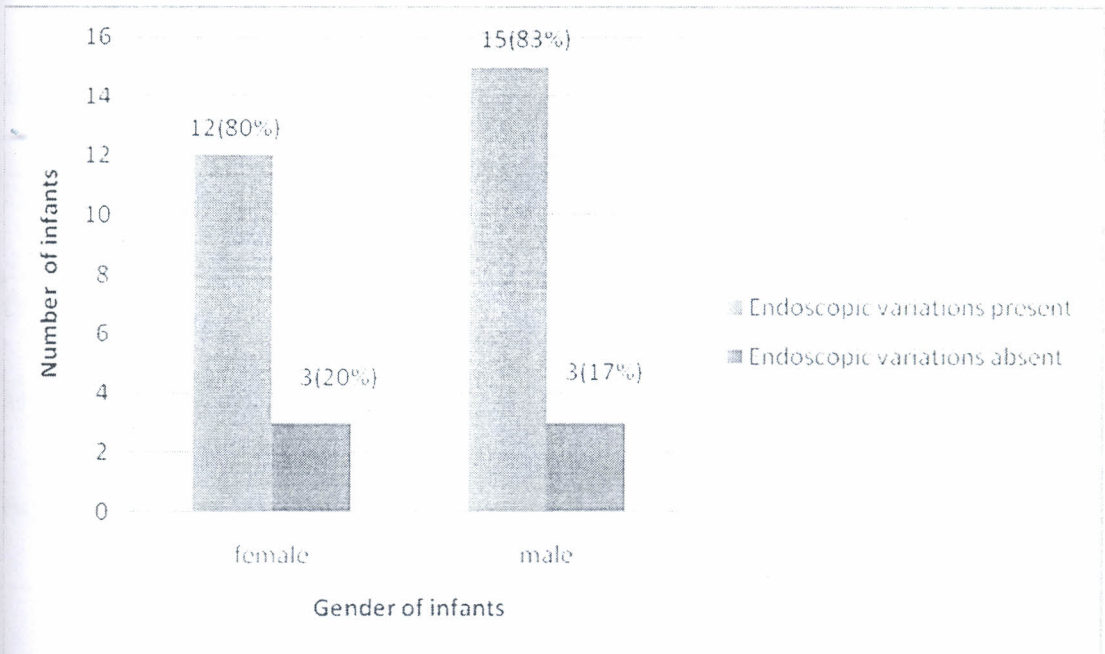
Characteristic	Variant ventricular findings Mean (SD)	Normal ventricular findings Mean (SD)	Difference [95% CI]	P value
Ventricular floor findings				
Age (months)	8.0 (1.0)	7.8 (1.02)	0.12 [-2.8 to 3.0]	0.93
Ventricular wall findings				
Age (months)	8.55 (0.76)	5.5 (1.52)	3.05 [-0.6 to 6.7]	0.094

The mean age of patients with variations in endoscopic ventricular wall findings was 8.55 months compared to 5.5 months among infants without variations (difference = 3.05, 95% CI [-0.6 to 6.7]). The patients with normal ventricular floor findings (mean age = 7.8 months) were only 0.12 months younger than those with variation in ventricular floor findings (mean age = 8.0). This difference in age was not statistically significant (p = 0.93).

Gender

Male infants comprised 54.6% (n = 18) of all the patients studied. The male to female ratio among infants recruited in this study was 1: 1.2. Figure 1 shows the distribution of variations in endoscopic findings among patients by their gender.

Figure 5: Distribution of variations in endoscopic ventricular findings among infants by gender



As shown in Figure 1 above the prevalence of variant endoscopic findings among male infants was 83% compared to a prevalence of 80% among female infants. The prevalence of variations in endoscopic findings did not show a statistical association with gender (chi = 0.06, p = 0.99), implying that male and female infants had a similar prevalence of variant findings.

Aetiology of hydrocephalus

Post infectious etiology, particularly sequelae arising from meningitis was the most common cause of hydrocephalus in this infant sample accounting for 72.7% (n = 24) of all the cases of hydrocephalus reported in this study. Table 3 lists all the causes of hydrocephalus recorded in this study and shows that the other major etiology of hydrocephalus is aqueductal stenosis responsible for 21.2% of the reported cases.

Table 3: Etiology of hydrocephalus among 33 infants investigated using ETV

Hydrocephalus etiology	**Frequency (n)**	**Percent**
Post – meningitis sequelae	24	72.7
Aqueductal stenosis	7	21.2
Myelomeningocele	1	3
Aqueductal stenosis, myelomeningocele	1	3

Myelomeningocele was identified as the primary cause of only one case of hydrocephalus, while it was among the two identifiable causes of a second case of hydrocephalus determined to have been caused by aqueductal stenosis and myelomeningocele (Table 3).

The result of the chi square test comparing frequency of variations in endoscopic findings among infants with various etiologies of hydrocephalus is presented in Table 4. In this study, reported variations in endoscopic findings were significantly associated with the etiology of hydrocephalus. (Chi =16.95, p = 0.001)

Table 4: Frequency of variations in ventricular endoscopic findings among infants with different hydrocephalus etiologies

Hydrocephalus etiology	Variant ventricular findings		Chi, p value
	Present	Absent	
Aqueductal stenosis	2 (25.6%)	5 (71.4%)	16.95, 0.001
Aqueductal stenosis, myelomeningocele	1 (100%)	0 (0%)	
Myelomeningocele	1 (100%)	0 (0%)	
Post - meningitis	23 (95.8%)	1 (4.2%)	
Total	27 (81.8%)	6 (18.2%)	

The finding of variation in ventricular endoscopy was significantly lower in infants with aqueductal stenosis compared to infants with other hydrocephalus etiologies (Table 4). Variant ventricular findings were present in 95.8% of infants with post-meningitis etiology compared to only 25.6% of infants with an aqueductal stenosis etiology who also had variations reported in their endoscopic findings.

Variations in ventricular endoscopic findings in infants with hydrocephalus

Table 5 lists the anatomic variations and anomalies occurring on the ventricle floor of hydrocephalic infants and visualized during ETV. Twenty two patients (66.67%) had normal ventricular walls. Out of the 11 infants with variations in ventricle floor features, seven (15.2%) had thick floor. This variation was the most commonly visualized ventricular floor anomaly and as shown in Table 5, did not impact on the success of ETV procedure.

The other ventricular wall variations reported among hydrocephalic infants were thickening of the floor sometimes occurring with opacification (6.1%) or formation of fibrous material (3.0%).

Table 5: Ventricular floor anatomic variations and anomalies in 33 infants undergoing ETV

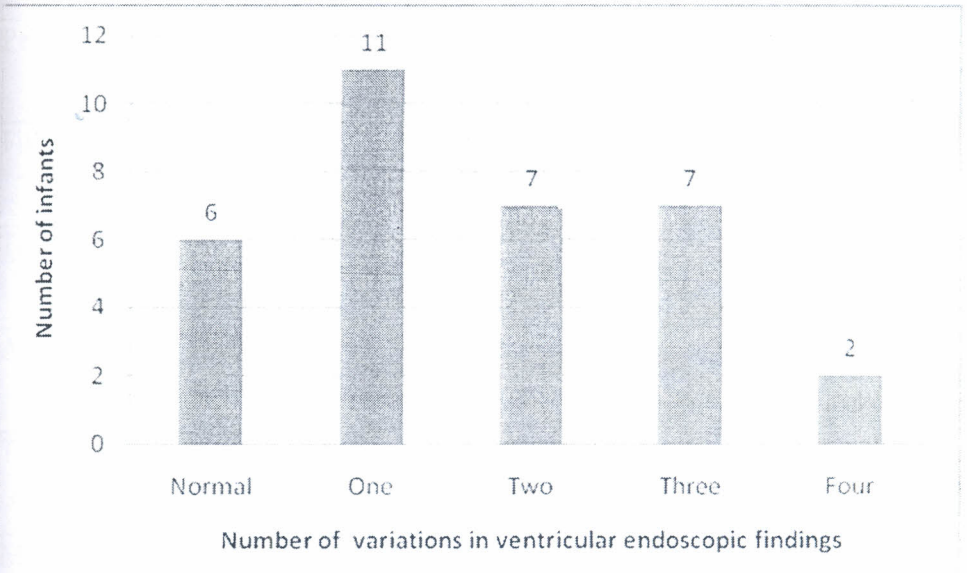
Anatomic variants/ anomalies	Frequency (%)
Normal ventricular floor	22 (66.67)
Thick floor	7(21.3)
Altered mammilary bodies	1 (3.0)
Fibrinous floor	1 (3.0)
Not visualized	1 (3.0)
Total	33 (100.0)

As shown in Table 5 above, alteration of the mammilary bodies was noted in one case. The ETV procedure was unsuccessful in an additional case as visualization of the ventricle floor

was not possible. Hydrocephalus in this patient in whom visualization of the ventricle floor was not possible was due to post-meningitic sequelae.

Considering endoscopic findings following inspection of the ventricular walls, patients commonly had more than one single variation reported during the ETV procedure. The number of anatomic variations visible on endoscopy among the infants in this study ranged from 0 to 4. Figure 7 shows the number of variations reported per patient. Out of the 33 infants, six (18.2%) had normal ventricular walls, 11 (33.3%) had one variation in ventricular findings and seven (21.2%) infants had two variations with a further seven (21.2%) exhibiting three ventricular wall variations.

Figure 7: Bar graph showing number of ventricular wall variations seen per infant



The specific endoscopic findings reported from examination of ventricle walls of infants with hydrocephalus are presented in Table 7. Six (18.2%) patients had normal ventricle walls.

The most common variation affecting the ventricular wall was petechiae reported in 54.4% of the infants with hydrocephalus, followed by fibrin strands which were visualized on the walls of ventricles in 30.3% of all the infants recruited in the study.

These anomalies were followed in frequency by two anatomical abnormalities namely, a thin fornix in 8 infants (24.2%) and an absent corpus callosum reported in 4 (12.1%) of the infants. The other less frequently reported variations are listed in Table 7 and included turbid CSF, cysts, atresias of the fornix and corpus callosum and exuberant hemosiderin collecting in fibrinous clumps.

Table 6: Ventricular wall anatomic variations and anomalies in 33 infants undergoing ETV

Anatomic variants/ anomalies	Frequency (%)
Petechiae	18 (54.5)
Fibrin strands	10 (30.3)
Thin fornix	8 (24.2)
Absent corpus callosum	4 (12.1)
Turbid CSF	4 (12.1)
Multiple cysts	3 (9.1)
Atretic corpus callosum	3 (9.1)
Exuberant hemosiderin forming clumps	1 (3.0)
Atretic fornix	1 (3.0)
Distorted anatomy	1 (3.0)

Outcome

ETV success rates

In 31 (93.9%) out of the 33 patients, ETV was completed and successful. The characteristic of the two patients in whom ETV was not successful are presented in Table 8. Both infants had hydrocephalus secondary to meningitis. In both cases visualization was obscured by turbid CSF and there were marked fibrinous deposits on the ventricle wall with thickened, opaque floor.

Table 7: characteristics of infants in whom ETV was unsuccessful

Characteristic	**Infant 1**	**Infant 2**
Age	1 year	2 months
Gender	Female	Male
Hydrocephalus etiology	Post-meningitis	Post-meningitis
Procedure duration	40 minutes	50 minutes
Variation in endoscopic finding	Yes	Yes

As shown in Table 7 above the infants' age and gender did not influence the success of ETV procedures in this sample.

ETV procedure times

The average time taken to complete an ETV procedure during the study was 36.8 (SD 9.4) minutes. The procedure's duration ranged from 22 minute to 60 minutes and was significantly influenced by factors like etiology of hydrocephalus, grade of hydrocephalus and findings of the procedure. The average procedure times and its association with these specific factors are presented in Table 8.

Table 8: Average procedure times among infants with different characteristics

Factor	**Average procedure time in minutes (SD)**	**ANOVA F, p value**
Hydrocephalus etiology		
Aqueductal stenosis	30.4 (5.5)	5.68, 0.024
Aqueductal stenosis, myelomeningocele	27	
Myelomeningocele	30	
Post – meningitis	39.4 (9.4)	
Variations on endoscopic finding		
Present	38.7 (9.3)	6.52, 0.016
Absent	28.6 (4.3)	

Results of the one way ANOVA test comparing the average time required to perform ETV procedure for the two most common etiologies showed that the etiology of hydrocephalus

significantly influenced the time taken for the procedure (F = 5.68, p = 0.024). On average, ETV procedures among patients with meningitis sequelae lasted 39.4 minutes compared to 30.4 minutes required to complete the procedure among patients with aqueductal stenosis, difference = 8.99 (95% CI 1.2-16.7) minutes.

Similarly, procedures conducted among patients with variations in endoscopic findings (mean = 38.7) on average took significantly longer to complete than those among patients with no variations (mean = 28.6 min) reported, difference = 10 (95% CI, 2 to 17.9) minutes (Table 9).

Concerning grade of hydrocephalus and ETV procedure time, there was a trend toward increasing duration of procedure with higher grades of hydrocephalus. (Table 9) Procedures conducted among patients with hydrocephalus and no variant findings lasted 29.2 minutes on average, and this time increase to more than 40 minutes for grades of hydrocephalus with findings of thick floor and obscured visibility (F= 6.52, p = 0.016).

Chapter 5: Conclusion and Recommendations

5.1 Conclusion

Variant findings in the third ventricle are a frequent finding during ETV. Successful perforation and shorter operation correlated with absence of anatomic variants. Anatomic variants increase the complexity of the operation as shown by the increased operating time with increasing variations. However, even with variant findings within the third ventricle, only inability to visualize the third ventricle resulted in incompletion of the procedure.

No complications occurred during the ETV procedures. This implies that the operation in infants is safe.

Variations in third ventricle findings seem to be determined by aetiology, with the majority of variations arising from hydrocephalus due meningitis. There seems to be no correlation between the anatomic variants seen following meningitis and the age of the infant.

Regarding the variations seen, 9 were noted in the third ventricle floor and 12 were seen in the wall of the third ventricle; more than one variation occurring within the third ventricle wall was a frequent observation.

5.2 Recommendations

- A proposed endoscopic anatomy classification should be implemented and used in determining infants in whom ETV can be performed.
- Based on endoscopic anatomy findings, patients who will benefit from ETV procedure can be selected.

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DATA COLLECTION SHEET

SECTION A:

TO BE COMPLETED BY THE PARENT/ GUARDIAN

REF NO: _____

DATE: _____

PERSONAL INFORMATION

NAME OF PATIENT: _____ ADDRESS: _____

HOSPITAL: _____ HOSPITAL ADMISSION NO: _____

AGE: _____ SEX: _____

SECTION B:

DIAGNOSIS/ETIOLOGY OF HYDROCEPHALUS

A) POST INFECTIOUS	YES	NO
B) NON POST INFECTIOUS	YES	NO
C) MYELOMENINGOCOELE	YES	NO

SECTION C:

FINDINGS ON NEUROENDOSCOPY

A) NORMAL ANATOMY	YES	NO
B) PETECHIAL HAEMORRHAGES ON THE VENTRICULAR WALL	YES	NO
C) FIBRIN STRANDS SEEN & ALTERED VISIBILITY ON STRUCTURES	YES	NO
D) THICK FIBRINOUS BANDS LAYERING VENTRICULAR WALL AND OBSCURING VISIBILITY	YES	NO
E) MULTIPLE CYSTS FORMED	YES	NO

DOCTOR'S NAME: _____

DOCTOR'S SIGNATURE: _____ DATE: _____

Information Sheet

Introduction

I am Dr. Benjamin Okanga. I am a postgraduate student at the University of Nairobi's Department of Surgery. I am part of a team of doctors performing a study on the different types of appearances of a part of the brain known as the Third Ventricle in children aged one year and below and who have hydrocephalus. Information regarding the study will be provided to you. Your child's participation in this study will enhance our understanding of this problem and will be highly appreciated. Participation in the study is entirely voluntary and you are free to withdraw your child at any time you wish. Standard treatment will be provided to your child. If you have any questions I will be glad to answer them and make clarifications. You can also raise any pertinent issues with the doctor treating you or the other staff members.

Purpose of the research

We are conducting this study to describe and document the appearance of the Third Ventricle as seen during a surgical procedure known as neuroendoscopy.

Patients presenting with hydrocephalus, which is an abnormally large amount of fluid in the brain and spinal cord, can have this fluid drained in different ways. One way involves making a small hole on the side of the head to where the fluid is contained in the part of the brain known as the Third Ventricle. Into this hole, an instrument known as a neuroendoscope is put in and is connected to a camera and a television screen. The neurosurgeon then perforates a membrane on the floor of the Third Ventricle to allow the fluid to drain. This procedure does not work for all patients with hydrocephalus. From previous studies and research, it is not clear what factors result in success or failure of this procedure in young children. Some studies suggest that

differences in the physical structure of the Third Ventricle may contribute to success or failure of this procedure.

In our study we will describe and document the appearance of the Third Ventricle in infants.

Participant selection

All children aged one year and below presenting with hydrocephalus and who will require surgery to divert cerebrospinal fluid are being invited to participate in this study with the permission of their parents or guardians.

Voluntary Participation

You are free to choose whether or not your child should participate in this study. If you decide not to participate, standard treatment shall still be given to your child. You may change your mind and withdraw your child from the study even if you had agreed earlier.

Procedures and Protocol

Patients to be included in the study are children aged one year and below with hydrocephalus and who will have surgery to drain excess cerebrospinal fluid.

Under general anaesthesia a burr hole will be made on the side of the child's skull to gain entry into the Third Ventricle by a qualified neurosurgeon. A neuroendoscope will be introduced into the ventricle. It will be connected to a camera and a television screen. The images will be recorded to aid in data entry in a pre-designed data collection sheet.

After the anatomy of the Third Ventricle has been recorded, the neurosurgeon will continue with the procedure to drain the cerebrospinal fluid according to standard treatment protocols.

Duration

This study does not include any further follow up for patients. Nonetheless, postoperative follow up will be carried out for each patient

Side Effects

The procedure is safe and we do not foresee any side effects. However, should any complications arise during the procedure, these will be treated accordingly

Benefits

Your participation in this study will contribute to the current body of knowledge regarding variant anatomy of the Third Ventricle in infants. It is intended to form a basis on which a classification system of Third Ventricle variant anatomy will be proposed.

Confidentiality

Any information collected about your child will be safeguarded and only the study team will have access to it. This information will be used for the study purpose only. Confidentiality will be maintained at all times.

Sharing the Results

The knowledge that we get from doing this study will be published in order that other interested people may learn from our research.

Right to Refuse or Withdraw

Your child does not have to take part in this research if you do not wish to include them. Your child will receive treatment that is the standard of care regardless of whether you choose to include them in the study or not. You may withdraw your child from participating in the study at any time that you wish without losing any of his/her rights as a patient here.

Whom to Contact

If you have any questions you may ask them now or later, even after the study has started. If you wish to ask questions later, you may contact any of the following:

Dr. Benjamin Okanga, Dept of Surgery, University of Nairobi

Mobile: 0721706782

Email: bjokanga@gmail.com

This proposal has been reviewed and approved by University of Nairobi's Department of Surgery and The Kenyatta National Hospital Ethics and Research Committee. The Aga Khan University's Research Committee has given provisional approval. This study is supported by the above committees whose task is to make sure that research participants are protected from harm. If you wish to find out more, you can contact the Aga Khan University Hospital's Research Committee on 0203662346 or Mr. Mungai Ngugi, the KNH Ethics and Research Committee Chairman on 0722708808.

CONSENT BY THE PARTICIPATING PATIENTS' PARENTS/ GUARDIANS

Study No.....

Hospital.....

Hospital No.....

Purpose of the study

The purpose of this study is to document the variant findings encountered during neuroendoscopy in infants at the Kenyatta National Hospital and the Aga Khan University Hospital. The information gathered will be used to classify the variant anatomy found at neuroendoscopy.

Risks and benefits

This study will provide clinicians essential information on the pattern and frequency of variant anatomic findings of the third ventricle in infants with hydrocephalus and may form the basis for future studies in which patients who will benefit from Endoscopic Third Ventriculostomy will be selected. There is no harm or risk anticipated for participating in this study. However, if a complication does arise while drilling a burr hole during neuroendoscopy or following the procedure, appropriate treatment will be given. No additional tests outside the usual ones for treatment will be carried out and no extra cost to you will be incurred for participating in the study.

Voluntary participation

Participation in this study is out of your own free will. Medical care will not be denied to your child in case you decline to participate in the study. You may terminate participation at any time with no consequences whatsoever.

Confidentiality

All information will be treated with confidentiality. Your child's identity will not be published.

I the undersigned have been explained to and understand the above and voluntarily accept to participate in the study.

Signature/Thumb print:

(Parent/Guardian) .....

Telephone number (parent/ guardian): .....

For any enquiries or further clarification, please contact the following:

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15th July 2010

f: KNH-ERC/ A/526

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ESEARCH PROPOSAL: "VARIATIONS IN VENTRICULAR ENDOSCOPIC FINDINGS IN INFANTS WITH 'DROCEPHALUS" (P207/06/2010)

his is to inform you that the KNH/UON-Ethics & Research Committee has reviewed nd **approved** your above cited research proposal for the period 15th July 2010 to 14th July 2011.

ou will be required to request for a renewal of the approval if you intend to continue with the study beyond the eadline given. Clearance for export of biological specimens must also be obtained from KNH/UON-Ethics & esearch Committee for each batch.

n behalf of the Committee, I wish you a fruitful research and look forward to receiving a summary of the research indings upon completion of the study.

his information will form part of the data base that will be consulted in future when processing related research tudy so as to minimize chances of study duplication.

ours sincerely

PROF A N GUANTAI
SECRETARY, KNH/UON-ERC

c.c. Prof. K. M. Bhatt, Chairperson, KNH/UON-ERC
The Deputy Director CS, KNH
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