Challenges and outcome of cranial neuroendoscopic surgery in a resource constrained developing African country

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Abstract

Background: Cranial neuroendoscopy has been safely applied to the surgical treatment of different lesions of the brain in our center since its introduction in September 2009. This article summarizes our experience with neuroendoscopy, highlighting the salient challenges and outcome.

Methods: A single institution, retrospective analysis of prospectively acquired cases over a 2.5-year period (September 2010 to February 2013). Challenges experienced during the course of patient care as well as complications and outcomes were recorded and analyzed using SPSS (SPSS Inc. Chicago IL, USA) version 17. Tests of statistical significance were set at 95% level.

Results: Of the 291 cranial procedures performed during the study period, 37 (12.7%) were neuroendoscopic interventions. Patients were between the ages of 0.25 years and 25 years with a mean of 5.7 ± 1.5 years (95% confidence interval (CI)). Aqueductal stenosis was the most common indication for endoscopic intervention in 22 (59.5%) patients. Endoscopic third ventriculostomy was the most commonly performed neuroendoscopic procedure in 21 patients (56.7%). Major challenges experienced were patient dependent in 28 ± 1.0 patients (95% CL), learning curve related in 21 ± 0.4 patients, and poor endoscopy support infrastructure in 15 ± 0.5 patients. Complications were significantly more common in the first 6 months of neuroendoscopy ($\chi^2 = 7.57$, df = 1, $P < 0.05$). Overall, 30 (81.1%) patients in our study experienced a positive outcome. The permanent morbidity and mortality rates in our series were 2.7% and 8.5%, respectively.

Conclusion: Highlighted are the myriad obstacles which interface the successful set up of neuroendoscopy service especially in resource-constrained settings. Endoscopic procedures become safer with experience and complications reduce significantly after a steep learning curve.

Key words: Challenges, developing country, neuroendoscopic surgery, outcome

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Introduction

Cranial neuroendoscopy permits effective surgical therapy of lesions in the depths of the brain with minimal collateral disruption of eloquent parenchyma. It is currently evolving popularity mirrors the diversity of increasing applications, which are also reflective of inherent limitations and challenges. Cranial neuroendoscopic procedures were first performed in our center and also our subregion by the corresponding author in September 2010. This article presents an analysis of our unit's experience over a 2.5-year period highlighting the challenges and outcome of cranial neuroendoscopy.

Methods

A single institution, retrospective analysis of prospectively acquired cases over a 2.5-year period (September 2010 to February 2013). Clinical data, as well as cranial computed tomography and magnetic resonance imaging reports, operation notes as well as follow-up records, were obtained and analyzed.

Inclusion criteria

All patients who had cranial endoscopic intervention in our unit within the study period were enrolled into the study.

Prior to the performance of endoscopic procedures, training on the basic principles and practice of cranial neuroendoscopy was organized for relevant theater and neurosurgical unit support staff, following which roles were distributed on the basis of demonstrably acquired competencies. Patients where possible or their first-degree relatives were interviewed at presentation. The endoscopic third ventriculostomy success score (ETVSS) of patients with hydrocephalus was also assessed. Endoscopic procedures were performed only when a favorable anatomy was confirmed intraoperatively. All endoscopy procedures were performed with a 0-degree rigid Wolf endoscope. Challenges experienced during the course of patient care, complications and clinical outcomes were recorded. The mean follow-up period was 1.87 ± 0.45 years (95% CL), range 10 months to 3 years. For patients with hydrocephalus, shunt independence was the primary outcome measure, and this was assessed using appropriate clinical status parameters such as occipitofrontal circumference (OFC), motor and cognitive milestones, symptom profile as well as supportive neuroradiological findings. For patients with intracranial cysts, the outcome was assessed using symptom profile and supportive neuroradiological features only. A positive response was defined as shunt independence or improvement in clinical status and neuro-radiological parameter(s) as outlined above. Data acquisition and analysis were performed using SPSS version 17 (SPSS Inc., Chicago IL, USA). Tests of statistical significance were set at 95% level.

Results

Among 291 cranial procedures performed during the study period, 37 (12.7%) were cranial neuroendoscopic interventions. Patients who received these procedures for the treatment of their lesions were between the ages of 0.25 years and 25 years with a mean of 5.7 ± 1.5 years (95% CL). Procedures were mostly performed in the pediatric age group (30 patients) and the indications for endoscopy also varied between pediatric and adult patients [Table 1]. Aqueductal stenosis (both congenital and acquired) was the most common indication for endoscopic intervention in 22 patients. Dandy–Walker syndrome (DWS) in 5 patients, 3 patients with aqueductal stenosis and 2 patients with DWS had intraventricular loculations. Arachnoid cyst in 7 patients, 3 patients had tumor associated obstructive hydrocephalus. Among neuroendoscopy procedures performed, ETV was the most common in 21 patients (56.7%), endoscope-assisted shunt placement in 5 patients. Fenestration of arachnoid cyst in 7 patients and aqueductostomy in 3 patients. Fenestration of arachnoid cyst were cystcisternostomies in 2 patients, ventriculocisternotomies in 5 patients. In 5 patients with intraventricular loculations, ETV was not possible due to unfavorable anatomy observed during

Table 1: Profile of endoscopic procedures and complications

	Pediatric cases	Adult cases	Mean ETVSS
Aetiology			
Aqueductal stenosis	20	2	80.9
DWS	5	0	72.0
Arachnoid cyst	4	3	NA
TAOH	1	2	86.8
Intraventricular loculations	5	0	77.2
Procedures			
ETV	17	4	
Aqueductostomy	3	0	
Endoscope-assisted shunt	5	0	
Arachnoid cyst fenestration	4	3	
Complications			
Intraventricular hemorrhage	1	0	
Sepsis	1	0	
CSF leak	3	1	
Abducens weakness	3	0	
Subdural hygroma	0	1	
Mortality	2	1	
Interval between surgery and complication (months)			
≤6	6	2	
>6	2	0	

χ^2=7.57; df=1; P<0.05. TAOH=Tumor associated obstructive hydrocephalus; ETVSS=Endoscopic third ventriculostomy success score; ETV=Endoscopic third ventriculostomy; CSF=Cerebrospinal fluid; NA=Not available; DWS=Dandy–Walker syndrome surgery and an endoscopic-guided ventriculoperitoneal shunt was performed instead. The mean ETVSS was 86.9 in patients with tumor-associated hydrocephalus, 80.9 in patients with aqueductal stenosis, and 72.0 in patients with DWS [Table 1].

Challenges experienced were patient dependent in 28 ± 1.0 patients (95% confidence interval). Patient-dependent factors included financial constraints in 27 ± 0.9 patients, poor acceptance as a result of ignorance in 26 ± 0.8 patients, negative cultural beliefs in 15 ± 0.5 patients. In 22 ± 0.8 patients, there were two or more patient related factors. Technical difficulties were experienced in 22 ± 0.6 patients. Technical challenges were learning curve related in 21 ± 0.4 patients, and endoscopy hardware failure in 10 ± 0.3 patients [Table 2]. Complications resulting were especially encountered during the initial 6 months and this was statistically significant ($\chi^2 = 9.25$, df = 1, $P < 0.05$) [Table 1]. The major institutional challenge experienced was poor endoscopy support infrastructure which adversely affected care in 15 ± 0.5 patients. 30 ± 2 (81.1%) patients experienced a favorable clinical outcome.

Sixteen of 22 (72.7%) patients with aqueductal stenosis had a favorable OFC and milestone response. Mean ETVSS among patients with aqueductal stenosis was 80.9, however among patients with aqueductal stenosis who had a positive clinical response, the mean ETVSS was 85 (ETVSS was 90 in 10 patients, 80 in 4 patients, and 70 in 2 patients). Among 5 patients with aqueductal stenosis who did not have a positive clinical response, the mean ETVSS was 64 (ETVSS was 60 in 3 patients and 70 in 2 patients). Three patients out of 5 nonresponders had ventriculoperitoneal shunt while the other 2 nonresponders died from sepsis and intracranial hemorrhage, respectively. Three (60%) patients with DWS experienced a positive response to ETV while 2 out 3 patients who had preresectional ETV for tumor-associated hydrocephalus had initial symptomatic improvement (1 of the patients died from tumor progression 3 months after ETV). Six of 7 patients who received arachnoid cyst fenestration had a positive response. One patient developed a complex subdural hygroma which was treated with subduro-peritoneal shunt. Complications were seen in 10 (27.0%) patients and were most common in the first 6 months of our study in 8 out of 16 (50%) patients treated while 2 of 21 (9.5%) patients treated after 6 months of commencement of endoscopic procedures experienced complications. Permanent morbidity was seen in only one (2.7%) patient with abducens weakness 7 of the 10 patients who experienced complications had ETV while 3 had fenestration of arachnoid cyst. The relationship between complication rate and temporal interval postneuroendoscopic surgery was statistically significant using Chi-square test ($\chi^2 = 7.57$, df = 1, $P < 0.05$ Table 1). Overall, 3 (8.1%) of the patients treated died. Cause of death was tumor progression in one patient, severe sepsis with renal impairment in one, and intraventricular hemorrhage in the remaining patient. All deaths occurred in patients who had ETV. Two of the three patients who died were also treated in the first 6 months of our neuroendoscopy experience.

Table 2: Challenges and outcome

	Number of patients
Challenges (95% CI)	
Patient factors	28±1.0
Financial constraints	27±0.9
Ignorance	26±0.8
Negative beliefs	15±0.5
2 or more factors	22±0.8
Technical factors	22±0.6
Learning curve	21±0.4
Hardware failure	10±0.3
Institutional impediments	
Poor infrastructure	15±0.3
Positive outcome	
Aetiology	
Aqueductal stenosis	18 (81.8)
DWS	3 (60)
TAOH	2 (67)
Arachnoid cyst	6 (86)
Procedures	
ETV	17 (81)
Arachnoid cyst fenestration	6 (86)
Aqueductostomy	3 (100)
Endoscope-assisted shunt	3 (60)

DWS=Dandy–Walker syndrome; TAOH=Tumor associated obstructive hydrocephalus; ETV=Endoscopic third ventriculostomy; CI=Confidence interval

However, the time interval postneuroendoscopic surgery was not statistically related to mortality profile using Chi-square analysis ($\chi^2 = 0.74$, df = 1, $P > 0.05$).

Discussion

The resurgence of neuroendoscopy can be traced to advancement in optics and computer technology.[1] Currently, its application in cranial neurosurgery has also advanced in scope.[2] Neuroendoscopy especially ETV has been shown to offer an acceptable low-cost alternative treatment to shunts especially in children with obstructive hydrocephalus in developing countries.[3,4] Endoscopic treatment of intracranial cysts has also been particularly successful in our experience as well as those of other neurosurgeons.[5-7]

In our previous study, we reported an initial experience with neuroendoscopy in our region.[5] This study presents our current experience and highlights the challenges we experienced in performing transcranial endoscopic surgery in our center which currently to our knowledge, is the only hospital within the South-East and South-South regions of our country offering neuroendoscopy service although centers from other regions have previously reported their experiences with ETV.[8,9] Unlike in our previous study which involved only children (age range 3–30 months), our current study population included both pediatric and adult patients (age range 0.25–25 years), however, the indications for endoscopy varied between pediatric and adult patient populations [Table 1]. Among the indications for neuroendoscopy, aqueductal stenosis has been previously associated with good success outcomes and is therefore widely regarded as the poster child for trancranial neuroendoscopy.[4,5,10,11] However, in our current study, we have found a more positive response with endoscopic fenestration of arachnoid cyst when compared with ETV for aqueductal stenosis [Table 2] (81.8% vs. 86%). Our previous experience was even more discrepant (80% for ETV and 100% for endoscopic fenestration).[5] The difference between our previous report and our current study may partly have resulted from the small sample size of our previous study in comparison to our current experience. Patients who had aqueductostomy for membranous aqueductal stenosis had the best outcome (100%). This suggests that even among patients with aqueductal stenosis, the pathologic type of aqueductal narrowing may have implications for selection of neuroendoscopic treatment options and outcome. Other causes of obstructive hydrocephalus such as DWS had lower ETV outcomes when compared to those with aqueductal stenosis [Table 1]. Although we did not perform choroid plexus cauterization (CPC), our outcome profile with ETV shows a higher positive response than those of comparable centers in Africa.[4,10] In the series by Warf *et al*.,[4] ETV with CPC was performed in patients with myelomeningocele and hydrocephalus. In comparison to our series, most patients who received ETV had aqueductal stenosis. We believe that differences in the etiology of hydrocephalus between the two study populations may contribute to the variation in outcome. ETVSS has been shown by the Canadian Paediatric Neurosurgery Group[12] to have an objective preoperative role in predicting ETV success. In their study, 305/455 ETVs (67%) were successful in the training set, while 105/163 ETVs (64.4%) were successful in the validation set. The predictive role of ETVSS score has also been validated by subsequent studies with higher ETVSS favoring higher ETV success outcomes.[13-15] In comparison to the outcome of studies cited above,[12,13] our study shows a higher success rate for ETV. This may partly be explained by the higher age distribution (mean = 5.7 ± 1.5 years) of our study population. ETV has been previously shown to have a higher success rate among older children than infants.[16-18] Our patients with arachnoid cysts treated by neuroendoscopic fenestration had an overall success rate of 86%. Endoscopic treatment of arachnoid cyst has also been reported to have a high success rate by other authors.[19-21] The overall complication rate in our study (27%) is higher than 8.5% reported in the systematic review by Bouras and Sgouros,[22] the permanent morbidity rate of our study (2.7%) is comparable to their reported value (2.4%). However, their review was limited to ETVs and involved 34 series of disparate patient populations. The systematic review cited above also reported a mortality rate of 0.21% which is lower than 8.1% we experienced in our study. The higher morbidity and mortality rates from our study could be partly the result of the challenges we experienced pioneering neuroendoscopy in a resource-limited region from a developing African country. These challenges were learning curve related in 21 patients. Association between learning curve and complication rate in the performance of neuroendoscopic procedures have been previously reported by other authors.[23] In the work by Schroeder *et al*., no incidences of mortality or permanent morbidity were experienced in the last 100 procedures.[23] In our experience, 80% of the complications (8) patients were observed during the first 6 months of our study and the relationship between interval from procedure and complication rate was statistically significant using Chi-square ($\chi^2 = 7.57$, df = 1, $P < 0.05$). No mortality or permanent morbidity was experienced among the last 15 patients treated in our study. Two of 3 cases of mortality were treated in the first 6 months, and all 3 were seen in the first 1 year of care. The challenging role of a learning curve experience in the outcome of neuroendoscopy should, therefore, be a major consideration when planning a neuroendoscopy practice. Hardware failure was experienced in 10 patients and included white balance and orientation problems as well as lighting source impediments including power outages which are prevalent in our society. Patient factors constituted a major challenge among those we treated with neuroendoscopy including financial constraints in 27 patients. We overcame the burden of financial constraints by making endoscopic treatment cheaper than ventriculoperitoneal shunt through the removal of shunt hardware cost. Twenty-six patients were ignorant of the existence or possibility of neuroendoscopic procedures. These and the 15 other patients (relatives) who had the negative belief that the process of looking into or operating in the brain with an endoscope would permanently harm the cognitive ability or quality of life of all the patients were quite tasking, but were eventually overcame through proper education which in some cases enlisted the help of other patients who have received neuroendoscopic treatment. These impediments together with the institutional challenge of poor endoscopy support infrastructure should duly be considered by neurosurgeons intending to commence neuroendoscopy in their practice. These are by no means the only impediments worthy of consideration. The challenge of training neurosurgery residents and support staff through courses, workshops, and fellowships and its role in shaping or reshaping a neuroendoscopy practice or program was not addressed by our current paper and we hope to look at any potential benefits accruable from such training in another paper. It is particularly interesting to note that infection following neuroendoscopy occurred in one patient (2.7%)

with ETV. Low infection rates have also been reported by other authors.[22,23] When compared to the shunt sepsis rate of 8.6% from our recently published article,[24] the low ETV sepsis makes this option a particularly attractive choice in our low-income environment. We performed aqueductal membrane fenestration (aqueductostomy) without ETV in 3 patients with membranous aqueductal stenosis. These patients remained shunt independent throughout the follow-up period. This may suggest the need to reclassify neuroendoscopy treatment options in patients with aqueductal stenosis on the basis of pathology subtypes. The feasibility as well as the efficacy of fenestration of membranous aqueductal obstruction has been reported previously by other authors.[25] Although, there is the report of a rare occurrence of pseudoaneurysm following endoscope-assisted shunt placement.[26] In our series, however, 3 patients (60%) treated had a positive outcome, while 2 experienced shunt complications. No patient in our series had any delayed vascular complication. We believe that endoscope-assisted shunt placement is a viable option especially for patients with multiple intraventricular cyst loculations after resection of compartments partitions with the endoscope and has also been reported to reduce the shunt revision rate in patients with loculated hydrocephalus.[7]

Conclusion

From our results, cranial neuroendoscopy offers a salient currency of hope in contemporary neurosurgical care especially in resource constrained environments because it offers the prospect of a more physiologic low-cost alternative intervention with low risk of complications in the follow-up period. Limitations to its full application may range from modifiable patient factors as well as learning curve and institutional limitations. Eliminating these impediments as well as refining tools and skills sets may help to properly define its role particularly in resource-limited centers as well as broaden its applications in synergy with other evolving technology driven minimally invasive neurosurgical interventions.

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Conflicts of interest
There are no conflicts of interest.

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