Early Outcome of Endoscopic Third Ventriculostomy With Choroid Plexus Cauterization Versus Ventriculoperitoneal Shunt as Primary Treatment of Hydrocephalus in Children With Myelomeningocele: A Prospective Cohort Study

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BACKGROUND: Myelomeningocele is associated with hydrocephalus in 35% to 90% of cases. Hydrocephalus is usually treated with insertion of ventriculoperitoneal shunt; however, there is growing evidence that endoscopic third ventriculostomy (ETV) with choroid plexus cauterization (CPC) is an alternative.

OBJECTIVE: To compare the success rate and morbidity of ETV with CPC and ventriculoperitoneal shunt (VPS) as the primary treatment of hydrocephalus in patients with myelomeningocele.

METHODS: A prospective study from January 2016 to February 2019, involving 46 patients with myelomeningocele who developed hydrocephalus after repair in a tertiary hospital in southwestern Nigeria. Biodata and preoperative features of hydrocephalus were documented. ETV + CPC or VPS was done using standard operative techniques. Patients were followed up monthly for 6 mo.

RESULTS: There were 23 patients in the ETV + CPC arm and 22 patients in the VPS arm. Morbidities were cerebrospinal fluid leak, 8.3% in the ETV + CPC arm and 4.5% in the VPS arm, wound dehiscence, 13.6% in the VPS arm, none in the ETV + CPC arm. At 6-mo follow-up, success rate for ETV + CPC was 60.9% and 59.1% for VPS, $P = .9$.

CONCLUSION: ETV + CPC had similar success rate with VPS at 6 mo with lower morbidity. ETV + CPC should be considered a viable alternative when treating patients with myelomeningocele and hydrocephalus.

KEY WORDS: Endoscopic third ventriculostomy, Myelomeningocele, Ventriculoperitoneal shunt, Choroid plexus cauterization

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The incidence of neural tube defects like myelomeningocele is reducing in many countries, but still remains a major challenge in low and middle income countries (LMICs). These children are either born with or go on to develop hydrocephalus (HCP).[1,2] Two studies reported neural tube defects incidences of 0.5 to 0.95/1000 live births in north central and 0.3/1000 live births in southern Nigeria, respectively.[3,4] It accounted for 76.9% and 83.8% respectively of the total number of patients with spina bifida in these hospital-based studies. Bankole et al[5] reported that myelomeningocele accounted for 95% of cases of neural tube defects presenting to the neurosurgery clinic in Lagos. The prevalence of myelomeningocele in the United States is 0.44/1000 live births and 0.74 to 2.5/1000 live births in the United Kingdom.[6] The incidence is 1.99/1000 live births in Yaoundé, Cameroun.[7]

ABBREVIATIONS: CPC, choroid plexus cauterization; **ETV,** endoscopic third ventriculostomy; **HCP,** hydrocephalus; **LMIC,** low and middle income country; **MMC,** myelomeningocele; **OFC,** occipitofrontal circumference; **TFUSS,** transfontanelle ultrasound; **VPS,** ventriculoperitoneal shunt

HCP is usually associated with myelomeningocele and it may be overt, presenting at birth or latent. It complicates 35% to 90% of myelomeningoceles.[8,9] HCP may become evident a few days to weeks following repair of myelomeningocele and about 84% to 89% ultimately require diversion of cerebrospinal fluid (CSF).[8,10]

HCP is conventionally treated by inserting a ventriculoperitoneal shunt (VPS) particularly in patients with myelomeningocele.[11] However, shunt insertion is fraught with complications. Steinbok et al[12] reported 86% failure rate in patients with spina bifida, with 51% failing within 1 yr of placement and an estimated 10% per year after 2 yr. Shunt infection occurs at a relatively high frequency, with typical reported rates of 5% to 10% but with values rising up to 19% in some series. It has been reported that shunt infection rates are higher in patients with myelomeningocele.[13,14] More recently, endoscopic third ventriculostomy with choroid plexus cauterization (ETV + CPC) is gaining popularity for the treatment of HCP in patients with myelomeningocele with comparably good outcomes.[10,15,16]

Being able to treat children with myelomeningocele that develop HCP successfully with ETV + CPC will provide an alternative to insertion of VPS. This will reduce the burden of shunt infection, malfunction, and other complications that bedevil shunt insertion. ETV + CPC also allows for cyst wall fenestration in patients with multiloculated HCP.[8,17]

METHODS

Study Design

A prospective interventional study of a cohort of patients was done between January 2016 and February 2019. Approval for the study was obtained from the Health Research and Ethics Committee. Informed consent was obtained.

Patients with myelomeningocele aged less than 2 yr that developed HCP post repair of myelomeningocele (MMC) were recruited for the study. Diagnosis was made clinically and with transfontanelle ultrasound (TFUSS) in most patients. A medium pressure Chabbra® shunt made by Surgiwear in India was used in all patients belonging to the VPS group, while a flexible 2.8 mm Karl Storz neuroendoscope was used for ETV + CPC following standard operating procedures.

Exclusion criteria were previous surgical treatment of HCP, hemorrhagic or infected CSF. Patients with overt HCP at birth were excluded from the study to ensure that a cohort with a uniform pathophysiology of HCP was recruited, such as obstruction at the incisura or the subarachnoid cisterns, loss of the dampening effect of the cystic mass, and further impaction of Arnold-Chiari malformation which result after repair of myelomeningocele.

A total of 49 patients were recruited sequentially, and the choice of surgery was based on the preference and familiarity of the attending consultant. Three patients were lost to follow-up and one excluded due to age.

Follow-up

Patients were followed up by the first author for 6 mo. Any patient who required another surgery, either a repeat shunt insertion or ETV + CPC for the treatment of HCP during the follow-up period was regarded to have a failed primary surgery. Surgery was regarded as successful if there was no further surgical procedure necessary for the treatment of HCP during the follow-up period. The occipitofrontal circumference (OFC), appearance of the anterior fontanelle, presence of distended scalp veins, setting-sun appearance of the eyes, evidence of infection, or wound complications were assessed monthly or at any time in between if a neurosurgical evaluation was clinically necessary. The OFC was measured in centimeters by a physician while the patient was upright with a nonelastic tape measure held a finger breath above the ears and the eyebrows and on the occiput. Two measurements were taken, and average measurement was used.

The anterior fontanelle was assessed with the patient in upright position; it was regarded as bulging when it was above the upper level of the surrounding outer table of the skull and nonbulging, if it was flush with or below the outer table of the surrounding skull.

A rate of head growth >0.5 cm/wk during the first 3 mo of life, >0.25 cm/wk during the second 3 mo of life and >0.5 cm/mo during the last 6 mo of the first year of life was regarded as excessive. OFC greater than 99th percentile or crossing percentile lines was used along with the clinical features to make a diagnosis of a failed primary surgery.

TFUSS was done to confirm persistent or worsening HCP for patients with suspected failure before repeat surgery. The primary outcome measure was shunt failure or ETV + CPC failure. Secondary outcome measures were complications of the surgery such as CSF leak, wound dehiscence, and shunt infection.

Data were analyzed using version 22 of Statistical Package for the Social Sciences (SPSS by IBM). All statistical analyses were done using descriptive and inferential statistics. Data were presented as the mean value ± standard deviation of the mean. Comparisons between groups were performed by Chi-square and logistic regression analysis. The confidence level was set at 95% and level of significance at $P \leq .05$.

RESULTS

A total of 23 patients had ETV + CPC (51.1%), while 22 patients had VPS insertion (48.9%).

The 6-mo success rate was 60.9% and 59.1% for the ETV + CPC and VPS arms, respectively; this was not statistically significant ($P = .9$). Survival analysis is shown in Figure. Approximately 44% (4 out of 9) of the shunt failure was due to shunt infection, 2 had proximal obstruction, 2 distal obstruction, and 1 had distal shunt migration.

The mean age at surgery was 13.3 wk ± 11.6 SD and 11.5 wk ± 10.3 SD for the ETV + CPC and VPS arms, respectively (Table).

The mean OFC at surgery was 44.9 cm ± 5.4 SD and 44.9 cm ± 4.9 SD for the ETV + CPC and VPS arms, respectively (Table).

The CSF was clear in 74% and xanthochromic in 26% of patients in the ETV + CPC arm. However, in the VPS arm, it was clear in 81.8% and xanthochromic in 18.2% of the patients.

There was no mortality in both arms of the study. Two patients (8.6%) had CSF leak after ETV + CPC as compared to 1(4.5%) case of CSF leak following VPS. Three patients (13.6%) in the VPS arm had wound dehiscence (also had shunt infection) but

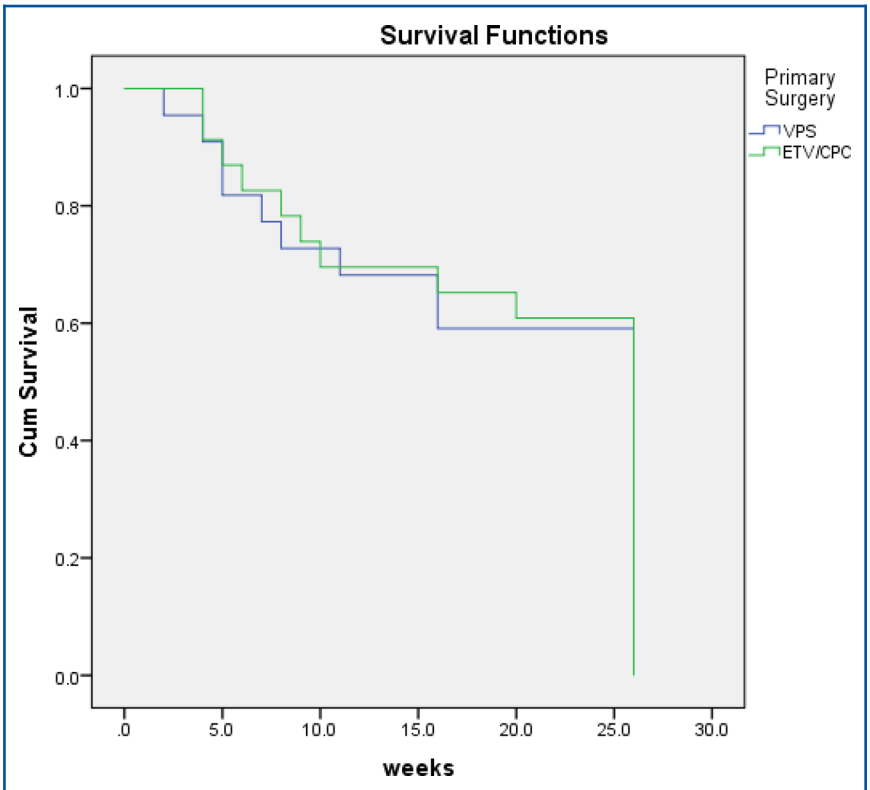

FIGURE. *Kaplan-Meier survival curve at 6 mo.*

TABLE. Matched Patients' Characteristics and Outcome

Variable	ETV + CPC	VPS
OFC (cm)		
Mean	44.9	44.9
Standard deviation	5.4	4.9
Minimum	36.5	38.0
Maximum	58.0	55.0
Gender (N)		
Male	17	10
Female	6	12
Total	23	22
Age (wk)		
Mean	13.3	11.5
Standard deviation	11.6	10.3
Minimum	1.0	1.0
Maximum	44.0	36.0
Outcome, N (%)		
Success	14 (60.9)	13 (59.1)
Failure	9 (39.1)	9 (40.9)

none in the ETV/CPC arm. There was no statistically significant difference in the incidence of CSF leak and wound dehiscence between the 2 groups using chi-square analysis (P value = .8 and .7) for CSF leak and wound dehiscence, respectively. The prepontine cistern was scarred in 4 (17.4%) patients and the floor of the third ventricle thickened in 10 (43.5%) patients in the ETV + CPC arm. The aqueduct was open in 10, narrow in 8, and closed in 5 patients, respectively.

The mean age for ETV + CPC failure was 6.8 wk and that for success was 17.4 wk, while mean age for success of VPS was 11.9 and 10.8 wk for failure. This observed difference was not statistically significant ($P = .31$).

Neither age at surgery nor the OFC at surgery correlated significantly with the outcome at 6 mo, using logistic regression analysis ($P = .4$ and .5) for age at surgery and OFC at surgery, respectively.

DISCUSSION

VPS remains the mainstay of treating HCP; however, studies now show comparative results with the use of endoscopic techniques among particular patient subsets. The success rate for ETV + CPC in this study is much lower than 87.5% previously reported in the same hospital by Bankole et al.[18] This difference may be due to fewer and older patients in the earlier study, and the reported success rate was obtained after subcategorization of overall success from a heterogeneous group of patients with various etiologies of HCP who had ETV + CPC. Kulkarni et al[19] reported an ETV + CPC versus VPS success rate of 52%

versus 72% at 6 mo in favor of shunt insertion. However, the study consisted of 2 disproportionate cohorts, the VPS arm was 20 times more than the ETV + CPC arm, patients with MMC were 11% and 22%, respectively, of the ETV + CPC and VPS arms, respectively. Recently, he reported 42% and 60% success rates at 6 mo for ETV + CPC and VPS, respectively.[20] Kulkarni's studies suggested superiority of shunt insertion to ETV + CPC, but Warf[10] documented 71% success rate with ETV + CPC among 328 children with myelomeningocele who required CSF diversion over a follow-up period of 5 yr. He observed that completeness of CPC was a predictor of success in his cohort, most of whom had ≥90% CPC. Although this variable was not directly assessed in this study, completeness of CPC did not appear to affect the outcome of the surgery because only 1 out of 4 patients who had incomplete CPC had a failed surgery. CPC was regarded complete when performed from the foramen of Monroe to the anterior tip of the temporal horns bilaterally and incomplete if the anterior tip of the temporal horn was not accessible or the choroid plexus was atretic. Stone and Warf[21] also reported a 74% success rate for patients with myelomeningocele who had de novo ETV + CPC. There was no comparative data with VPS in their respective studies.

The failure rate of ETV + CPC (39.1%) in this study was higher than that reported by Beuriat et al,[22] 28% for ETV + CPC among 32 patients; however, he reported a higher failure rate with VPS, 50% of 18 patients in his cohort compared with 40.9% in this study. Dewan et al,[23] in a retrospective review of 44 patients, reported 57% ETV + CPC failure rate at a median time of 51 d postoperatively. Alatas et al reported 13% VPS failure rate at 1 yr among 39 patients, while Caldarelli et al reported 45.9% shunt failure rate among 170 patients, 86% of which occurred in 6 mo, higher than the finding of this study.[24] The observed differences in shunt failure rates may be a reflection of the local infection rate and differences in the sample size of the various studies.

Age of Patients for a Successful or Failed Procedure

The median ages of the patients for a successful ETV + CPC and VPS were 14 and 7 wk, respectively. However, the mean and median ages of the patients for a failed of ETV + CPC and VPS were 6.8 and 4 and 10.9 and 7.5 wk, respectively. This was similar to a median age for failure of 30 d reported by Kulkarni et al[19] in a cohort of 36 patients who had ETV + CPC. Similarly, Warf and Campbell[25] reported that mean and median ages for failure was 2 mo but the mean and median age for success were 2 and 3.3 mo, respectively, which were slightly lower than the findings of this study. It was observed that failure of ETV + CPC was higher among patients less than 6 mo as reported by other authors.[26-28] This suggests that the success of ETV + CPC relies on the maturation of adequate CSF channels in Vivo, and this takes several weeks to develop in this subset of patients.

Determinants of Outcome at 6 Months

This study revealed that mean ages for patients with a failed surgical outcome were 6.8 and 10.8 wk for ETV + CPC and VPS, respectively. However, this was not found to be statistically significant ($P = .16$). This contrasts the findings of Kulkarni et al[19] who reported that age at surgery was an important predictor of ETV + CPC success, though not a predictor of time to failure. Dewan et al[23] also reported that younger age was associated with failure of ETV + CPC (0.8 versus 3.9 mo, $P = .01$) among a cohort of 44 patients. This study revealed that the success rate was low in patients less than a month old at the time of surgery and that all patients greater than 6 mo old had a successful ETV + CPC, though not statistically significant. This lack of statistical significance may be due to the smaller sample size of this study. Stone et al[29] reported that age at surgery <6 mo and prepontine scarring were predictors of failure of ETV + CPC, but patency of the aqueduct had no effect on failure nor success.

Preoperative ETV success scoring revealed that 75.5% of the patients had a low score ≤40, while 24.5% has a moderate score of 60 to 70 and no patient had a high score, ie, ≥80. This finding suggests that the use of Endoscopic Third Ventriculostomy Success Score in this category of patients tends to underestimate the likelihood of successful ETV and as such should be used with caution in determining which children to perform ETV + CPC on.

Age Distribution

The demographic pattern of this study was similar to that reported by Dewan et al[23]; mean age for ETV/CPC and VPS treated patients was 3.4 and 2.9 mo, respectively. However, Biluts and Admasu[30] reported a lower mean age at ETV + CPC of 1.9 mo in a cohort of 122 patients. Similar to the finding of our study, Warf and Campbell[25] reported mean and median ages at ETV + CPC of 3 and 2 mo respectively in a cohort of 115 patients and Wang et al[29] reported that the median age was 3.2 mo at surgery.

OFC at Surgery

There was no significant statistical difference between mean OFC at surgery among the 2 groups. The mean OFC in this study was less than that reported by Biluts and Admasu[30] who reported mean and median head circumference of 52.78 and 53.0 cm, respectively, at the ETV + CPC.

This difference in mean OFC at surgery is a reflection of the time patients presented for surgery in these studies.

Morbidity and Mortality

The observed morbidities from this study differ from that reported by Kulkarni et al,[19] who reported postoperative seizure in 5.1% of the patients, postoperative hemorrhage in 3.4% of patients, and 2 mortalities following ETV + CPC. Weil et al[31] reported an overall morbidity of 3.7% with ETV + CPC which included subdural hygroma, CSF leak, and ventriculitis.

The shunt infection rate of this study was higher than 11% reported by Beuriat et al[22] among 18 patients. Our shunt infection rate was similar to that reported by Komolafe et al[32]

in South Western Nigeria among patients with HCP of various etiologies. The shunt infection rate of this study was also higher than the infection rate of 5% reported by Alatas et al[24] and 12.3% reported by Caldarelli et al.[33] Surgical infection rate is usually attributed to factors which range from systemic deficiencies to operator dependent variables. All shunts were inserted by senior resident doctors and consultants in this study. Extrapolation of the data in a different setting, eg, high-income countries, may be limited since the infection rate from shunting is higher in LMICs.

Limitations

Limitations of this study include lack of randomization of patients as well as lack of blinding to the procedure performed during follow-up. Both of these may have introduced bias in assigning patients to the treatment group and in evaluation and determination of failure. This selection bias may introduce confounding factors that may have affected some of the outcomes of the study. The relatively small sample size also reduces the power of the study and as such the findings of the study may have to be interpreted with some caution since studies with higher power may reveal slightly different findings especially with regard to statistical significance. Furthermore, a longer follow-up period may be required to give more validity to the findings of this study.

CONCLUSION

ETV with CPC is a viable alternative to VPS as primary treatment of HCP post repair of MMC. It has a comparatively similar success rate at 6 mo postoperatively with VPS and lower morbidity than VPS insertion.

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