The Egyptian Journal of Hospital Medicine (October 2022) Vol. 89 (2), Page 8016- 8022

Clinical and Radiological Outcome after Endoscopic Third Ventriculostomy with or without Choroid Plexus Cauterization in Management of Pediatric Hydrocephalus

Mahmoud Mostafa Taha, Ahmad Mohamad Easa El-Sharkawy,
***Hend Shaban Mohamed Al-Shara, Amr Mohamed Mohamed Al-Bakry**
Department of Neurosurgery, Faculty of Medicine, Zagazig University, Sharkia, Egypt
***Corresponding author:** Hend Shaban Mohamed Al-Shara, **Mobile:** (+20) 01552829866 , **E-mail:** rosetripoli7982@gmail.com

ABSTRACT

Introduction: Different surgical management of infants suffering from hydrocephalus was reported. There is much debate regarding the management of pediatric hydrocephalus and whether endoscopic third ventriculostomy (ETV) combined with choroid plexus cauterization (CPC) is superior to ETV alone. **Aim of the study:** To evaluate the outcome of the Endoscopic Third Ventriculostomy (ETV) and ETV-CPC procedures as surgical options for selected forms of hydrocephalus.

Patients and methods: A prospective cohort study was conducted on 18 patients aged not more than 6 years old, who have the etiology of non-communicating hydrocephalus as confirmed by clinical picture and neuroradiological imaging whether previously shunted or not. Patients older than 6 years old, and who refuse the study were excluded. We measured the ETV success score in all cases preoperatively which depends on age, etiology, and previous shunt insertion

Results: In ETV+CPC incidence of improvement was 100% compared to 28.6% in the ETV technique, the difference statistically significant.

Conclusion: The combination of ETV and CPC may improve outcomes for infants with hydrocephalus. With a low but significant risk profile, ETV/CPC remains a viable, effective procedure for reducing the need for VPS in Egypt.

Keywords: Ventriculostomy, Hydrocephalus, Endoscope.

INTRODUCTION

The symptomatic buildup of cerebrospinal fluid (CSF) inside the cerebral ventricles is known as hydrocephalus. This buildup could be caused by a blockage in the CSF's normal flow, an issue with the arachnoid granulations' ability to absorb blood into the veins, or an excessive amount of CSF being produced[(1)].

The choroid plexus produces CSF in the ventricles. It moves through the brain's ventricular system before entering the bloodstream. CSF serves a variety of purposes and is constantly circulated. It serves as an injury-prevention cushion and envelops the brain and spinal cord. Proteins and nutrients found in CSF are essential for the brain's normal nutrient uptake and maintenance. It removes waste from tissues nearby by carrying it[(2)].

The first course of treatment is a ventricular shunt insertion during surgery. In appropriate cases of hydrocephalus, endoscopic third ventriculostomy (ETV) and choroid plexus cauterization are potential treatments. Without timely treatment, acute hydrocephalus can lead to brain herniation and perhaps death. Depending on how long the follow-up is, the death rate for children with hydrocephalus ranges from 0% to 3%[(3)].

Aqueductal stenosis, brain abnormalities, and spina bifida are the three most frequent causes of congenital hydrocephalus. When there is an imbalance in the amount of cerebrospinal fluid (CSF) produced and absorbed, or in the way it circulates, it can result in brain hydrocephalus. The way the imbalance manifests itself is one method to categorize this illness. There are primarily two approaches: obstructive "non-communicating" and non-obstructive "communicating." When the CSF runs out of the ventricles of the brain and into the spinal canal without being properly reabsorbed by the tissue surrounding the brain and spinal cord, this condition is known as nonobstructive "communicating" hydrocephalus. Post-hemorrhagic or post-inflammatory alterations are the most frequent causes. One-third of these instances are attributable to subarachnoid hemorrhage, which prevents CSF absorption at the arachnoid granulations. Hydrocephalus can make meningitis, particularly bacterial meningitis, more problematic. Adult hydrocephalus is significantly influenced by head trauma in the industrial environment [(2)]. On the other hand, obstructive, or noncommunicating, hydrocephalus happens when there is an impediment, such as a deformity or narrowing, that prevents the CSF from flowing adequately between or out of the brain ventricles. The Monro foramina, the aqueduct of Sylvius, the fourth ventricle, and the foramen magnum are where it occurs most frequently, however, most tumors with a substantial size can impede CSF channels elsewhere. Ependymoma, subependymal giant cell astrocytoma, choroid plexus papilloma, craniopharyngioma, pituitary adenoma, hypothalamic or optic nerve glioma, hamartoma, and metastatic tumors are a few of the most common tumors linked to hydrocephalus. Tumors in the posterior fossa are frequently linked to the emergence of hydrocephalus[(4)].

Due to the observed rise in shunt failure rates across the nation, endoscopic third ventriculostomy (ETV) with or without choroid plexus cauterization (CPC) has been recommended as the primary

Received: 17/7/2022
Accepted: 19/9/2022

management for some cases of pediatric hydrocephalus. Since the use of these surgical techniques to treat hydrocephalus is relatively new in our nation, little is known about the results. The effectiveness of ETV alone and in conjunction with CPC as the primary treatment for pediatric hydrocephalus is being investigated in light of this development[5]. So we aimed in this study to assess the efficacy of Endoscopic Third Ventriculostomy (ETV) and ETV-CPC procedures as surgical options for certain types of hydrocephalus.

PATIENTS AND METHODS

The study was performed in the Neurosurgery Department of Zagazig University hospital during the period from January 2022 to September 2022. This prospective cohort study was conducted on 18 patients having non-communicating hydrocephalus attending the outpatient clinic of the Neurosurgery Department of Zagazig University hospital during the period from January 2022 to September 2022 that treated surgically using neuroendoscopy.

Patients with age not more than 6 years old, having an etiology of non-communicating hydrocephalus as diagnosed by clinical picture and neuroradiological imaging whether previously shunted or not were included. Patients older than 6 years old, and who refuse the study were excluded.

All patients were subjected to careful history taking, and complete neurological examinatioN= The diagnosis of hydrocephalus and its cause were established by the clinical picture, neuroradiological imaging including CT or MRI brain, routine laboratory investigations were done on all patients before surgery. We measured the ETV success score in all cases preoperatively which depends on age, etiology, and previous shunt insertion[6].

Surgical Management: Surgery aimed to bypass the obstructed CSF pathways to treat hydrocephalus. The neuroendoscopic techniques used were endoscopic third ventriculostomy (ETV) in 14 cases and choroid plexus cauterization (CPC) with ETV in 4 cases.

The patients were monitored in the postoperative period for the following: clinical follow-up, head circumference, condition of the anterior fontanelle if opened, seizure, signs of increased intracranial pressure "ICP", milestone assessment, and image follow-up.

Ethical approval:

Both the institutional review board and the local committee of ethics approved the protocol of this research in the Faculty of Medicine of Zagazig university and was performed based on the Helsinki DeclaratioN= Written consent for being informed was collected from all participants before their involvement in this study.

Statistical Analysis

SPSS 20.0 for windows (SPSS Inc., Chicago, IL, USA 2011) was utilized during the entire process of data collection, tabulation, and statistical evaluatioN= The mean and standard deviation were used to convey the quantitative data, while absolute frequencies (number) and relative frequencies were used to express the qualitative data (percentage). The t-test was utilized to compare two independent variables that were normally distributed against one another. When applicable, the Chi-square test or Fisher's exact test was utilized to make comparisons between percentages of categorical variables. During at least three different time points, the ordinal variables of the subjects were measured with the use of the Friedman test. Each test had two parts. A statistically significant (S) result was regarded to have a p-value of less than 0.05, whereas a statistically insignificant result had a p-value of more than 0.05. (NS).

RESULTS

Table (1): Demographic characters of the studied group

Variable	The studied group (18)	
Age per month		
○ **Median (Range)**	10.5 (6-48)	
○ **<12**	11(61.1%)	
○ **≥12**	7(38.9%)	
Gender	**N=(18)**	**%**
○ **Females**	7	38.9
○ **Males**	11	61.1
Neuroendoscopic techniques		
ETV	**14**	**77.8**
ETV+CPC	4	22.2
ETV success score		
Mean ±SD	19.3± 57.8	
Range	30-80	

Table (1) shows the included 18 patients, their ages ranged from 6-48 months with a median of 10.5 months. Females were 7(38.9%), while 11 patients were males (61.1%). The most common procedure was ETV alone and the least common one was ETV+CPC. The mean ETV success score was 19.3±57.8 with a range from 30-80.

Table (2): Mean head circumference (cm) and Communication level throughout study phases assessment by age and stages questionnaire

		Surgical procedure			
		ETV N=14		ETV+CPC N=4	
Head circumference(cm) before surgery (Mean ±SD)		48.05±0.97		49±2	
Head circumference(cm) after 1 month (Mean ±SD)		47.14±1.5		48.25±2.5	
Head circumference(cm) after 3 months (Mean ±SD)		46.36±1.6		46.5±3.78	
Head circumference(cm) 6 months (Mean ±SD)		45.18±2.5		45.25±3.86	
P1 within group		0.034		0.032	
	ETV (N=14)			**ETV+CPC (N=4)**	
	Level	**N**	**%**	**N**	**%**
Communication before	On schedule	6	42.9	4	100.0
	need monitor	8	57.1	0	.0
Comunication1 month post operative	On schedule	8	57.1	4	100.0
	need monitor	3	21.4	0	.0
	Impaired	3	21.4	0	.0
Comunication3 month post operative	On schedule	9	64.3	3	75.0
	need monitor	2	14.3	1	25.0
	Impaired	3	21.4	0	.0
Communication6 month post operative	On schedule	9	64.3	4	100.0
	need monitor	0	.0	0	.0
	Impaired	5	35.7	0	.0
P1		0.724		0.39	

Table (2) shows: In the ETV technique; there is a significant decrease in mean head circumference throughout study phases, $p< 0.05$. In the ETV+CPC technique; There is a significant decrease in mean head circumference throughout the study phases, $p<0.05$. In both ETV and ETV+CPC techniques; There is no significant difference in communication level throughout the study phases, $p>0.05$.

Table (3): Problem-solving level throughout study phases assessment by age and stages questionnaire.

	Surgical procedure				
	ETV N=14			ETV+CPC N=4	
	Level	**N**	**%**	**N**	**%**
Problem-solving before	On schedule	3	21.4	0	.0
	need monitor	4	28.6	2	50.0
	Impaired	7	50.0	2	50.0
Problem-solving1 month post operative	On schedule	3	21.4	0	.0
	Need monitor	11	78.6	4	100.0
Problem-solving 3 month post operative	On schedule	6	42.9	3	75.0
	need monitor	8	57.1	1	25.0
Problem-solving 6 month post operative	On schedule	8	57.1	2	50.0
	need monitor	6	42.9	2	50.0
P		0.0001		0.064	

Table (3) shows: In ETV and ETV+CPC techniques; There is a significant improvement in problem-solving throughout the study phases p=0.0001, 0.064.

Table (4): Personal social level throughout study phases assessment by age and stages questionnaire.

	Surgical procedure				
	ETV N=14			ETV+CPC N=4	
	Level	N	%	N	%
Persona social before	On schedule	3	21.4	0	.0
	need monitor	4	28.6	2	50.0
	Impaired	7	50.0	2	50.0
Personal social1 month post operative	On schedule	3	21.4	0	.0
	need monitor	11	78.6	4	100.0
Personal social 3-months post operative	On schedule	6	42.9	0	.0
	need monitor	8	57.1	4	100.0
Personal social 6-months post operative	On schedule	6	42.9	2	50.0
	need monitor	8	57.1	2	50.0
P1		0.0001		0.072	

Table (4) shows: In ETV and ETV+CPC techniques; There is a significant improvement in personal social level throughout study phases p=0.0001, 0.072.

Table (5): Mean Evan ratio throughout study phases.

	Surgical procedure	
	ETV N=14	ETV+CPC N=4
Evan's ratio before surgery Mean ±SD	0.686±0.102	0.6±0.14
Evan's ratio after 1 month Mean ±SD	0.675 ±0.11	0.6±0.14
Evan's ratio after 3 months Mean ±SD	0.557±0.17	0.5±0.14
Evan's ratio 6 months Mean ±SD	0.564±0.22	0.45±0.1
P1 within group	0.58	0.009

Table (5) shows: Evan's ratio is stable at one-month postoperative in both techniques otherwise: in the ETV technique; there is a significant decline in the mean of Evan's ratio at 3,6 months but not reached normal size throughout the study phases. In the ETV+CPC techniques; There is a significant decrease in the mean of Evan's ratio throughout the study phases, p=0.009.

Table (6): Comparison between endoscopic third ventriculostomy with or without choroid plexus cauterization in the management of pediatric hydrocephalus regarding postoperative outcome and complications.

Post-operative outcome	ETV N=14		ETV+CPC N=4		p-value
	N	%	N	%	
Head circumference					
○ Enlarged ○ Improved	5 5	35.7 35.7	0 3	0.0 75.0	0.28
Developmental assessment					
○ Improved	4	28.6	4	100.0	**0.045**
○ Not improved	4	28.6	0	0.0	0.65
○ Same	6	42.8	0	0.0	0.32
Postoperative seizure	5	35.7	0	0.0	0.28
Increase in ICP	5	35.7	0	0.0	0.28
Postoperative complications					
Fever	6	42.9	0	0.0	0.25
Infection	4	28.6	0	0.0	0.52
Hemorrhage	1	7.1	2	50.0	0.11
CSF leakage	2	14.3	0	0.0	0.99
Pnemocephaly	2	14.3	0	0.0	0.99
Mortality	0	0.0	0	0.0	-

Table (6) shows: In ETV+CPC incidence of improvement was 100% compared to 28.6% in the ETV technique, and the difference was statistically significant. Otherwise, there is no significant difference between both techniques regarding the postoperative outcome. There is no significant difference in ETV, ETV+CPC neurological procedures regard happening postoperative complications, p>0.05.

DISCUSSION

The study included 18 patients, their ages ranged from 6-48 months with a median of 10.5 months. Females were 7 (38.9%), while 11 were males (61.1%).

Dewan *et al.*[7] in a study that looked at patients' postoperative clinical metrics and compared those who had failed or succeeded with ETV/CPC, the researchers looked at the data retrospectively. The mean age was 3.9 months, 57% were males and 43% were females. Their mean age of cases was younger than ours. Also, **Pindrik *et al.*[8]** in their 32 patients were included in the study, with 53% of them being male and 47% being female. The mean patient age at first ETV/CPC was 17.1 weeks (standard deviation: 20.0 weeks; range: 0.4–96.9 weeks) (representing the actual age since birth).

Concerning the neuroendoscopic techniques used for the treatment of hydrocephalic children, ETV alone was done in 14 cases. ETV + CPC was done in four cases.

Among 443 patients younger than one-year-old, the addition of CPC to standard ETV improved the success rate from 47% (ETV alone) to 66% (ETV + CPC), with particularly positive results among patients with hydrocephalus secondary to myelomeningocele or noninfectious causes. The success rate improved from 47% (ETV alone) to 66% (ETV + CPC)[9].

Our findings reported that the mean ETV success score was 57.8±19.3 with a range from 30-80.

A previous study reported that the mean percentage of EVT success was 37.9% in Uganda compared with 57.4% in developed nations [10]. A recent study reported that the median ETV success score was 50. Successful ETV was performed in 86.6% of patients (n = 71) [11].

ETV/CPC exhibited a soberingly low success rate of only forty percent in a select group of patients suffering from posthemorrhagic hydrocephalus of prematurity. Importantly, it was found that all patients whose cisterns were unobstructed had successful therapy, in contrast to the 86 percent of patients whose cisterns were obstructed who had unsuccessful treatment. This conclusion

confirms the findings of the study on myelomeningocele[12].

Concerning head circumference through study phases (preoperative, post 1, 3, and 6 months), in the ETV technique, the mean value experienced a significant drop in head circumference throughout the study phases ($p<0.05$). In the ETV+CPC technique, there was a significant decrease in the mean head circumference throughout the study phases ($p<0.05$).

In accordance with the present study, **Dewan *et al.*** [7] documented that head circumferences (HC) of all patients had ventriculomegaly.

Respecting communication level t the current study, in both ETV, and ETV+CPC techniques, there was no significant difference in communication level throughout the study phases ($p>0.05$).

Regarding the gross motor level, in the ETV technique, throughout the different phases of the trial, there was a considerable improvement in gross motor functioN= In the ETV+CPC technique, there was a significant improvement in gross motor throughout the study phases.

Respecting fine motor level, in the ETV technique, there was a significant improvement in fine motor throughout the study phases.

In the ETV+CPC technique; there is no significant improvement in gross motor throughout the study phases.

Regarding problem-solving levels throughout the study phases, In ETV and ETV+CPC techniques, there was a significant improvement in problem-solving throughout the study phases.

The ongoing clinical trials that are assessing long-term neurocognitive results will provide answers to the most significant unanswered concerns regarding ETV/CPC. The trial that was just described, as well as the plans for an HCRN trial that will compare neurocognitive results in the industrialized world, will be an important step toward answering the issues that were asked. A prospective ETV/CPC study that is now being conducted by the HCRN should serve to further explain elements that indicate success and build a scoring system to predict success. Imaging methods and findings that preoperatively indicate better candidates for ETV/CPC will be the primary focus of the studies to be conducted [13].

Concerning personal social level in the present study, In ETV and ETV+CPC techniques, there was a significant improvement in personal social level throughout the study phases.

Regarding Evan's ratio throughout the study, there was stability in Evan's ratio at one-month postoperative in both techniques. Otherwise, in the ETV technique, there was a significant decline in the mean of Evan's ratio at three and 6 months but did not reach normal size throughout the study phases. In the ETV+CPC technique, there was a significant decrease in the mean of Evan's ratio throughout the study phases.

Santamarta *et al*. [14] It has been noted that the behavior of all four ventricular ratios is quite consistent with one another. If ETV is shown to be clinically effective, there is a reduction in the size of the ventricles, however, if there is no clinical improvement, the size of the ventricles does not change. When comparing the two group's ventricular sizes using the Evans index ($p = 0.0004$), the third ventricle index ($p = 0.008$), and the ventricular score (p 0.01), there is a statistically significant difference between the two. When the ventricles, however, are measured using the cella media index ($p=0.08$), differences become significant enough to be considered a trend. For all ventricular ratios, the decline is more noticeable in acute hydrocephalus than in chronic forms, except for the Evans index ($p=0.12$), which shows no significant difference between the two.

Respecting the overall outcome, in ETV+CPC incidence of improvement was 100% compared to 28.6%. in the ETV technique, $p = 0.045$ indicates that the difference is statistically significant. Otherwise, there was no significant difference between both techniques regarding the postoperative outcome. Regarding postoperative complications of both neurological procedures, there was no significant difference in ETV, ETV+CPC.

Following the current study, **Kulkarni *et al*.**[10] revealed that the most common complications of ETV+CPC included seizures (5.1%), postoperative hemorrhage (3.4%), and CSF leak (3.4%). There was no infection or pseudo meningocele. Seizures were the most common postoperative consequence, occurring in five and a half percent of patients. Five of these infants had a corrected age of less than one month, and five of them experienced bleeding while they were being operated on (4 mild and 1 severe). Myelomeningocele was the cause of death in three of the infants, whereas intraventricular hypertension of premature birth, aqueductal stenosis, and another condition was each responsible for the death of one infant.

CONCLUSION

There is a possibility that the ETV and CPC when coupled will result in better results for infants who have hydrocephalus. ETV/CPC is still a realistic and effective method for minimizing the need for VPS in Egypt, although there is a low but significant risk profile associated with it. It seems likely that ETV/CPC will continue to be a cornerstone in the treatment of baby hydrocephalus in this country given the limited access to neurosurgical therapy that is available. According to the findings of our research, aqueductal stenosis continues to be one of the most common causes of hydrocephalus

among the etiologies of non-communicating hydrocephalus.

Declaration of conflict of interest

There was no disclosure of any possible conflicts of interest related to the research.

Funding: no funding.

REFERENCES

1. **Chen S, Luo J, Reis C *et al.* (2017):** Hydrocephalus after Subarachnoid Hemorrhage: Pathophysiology, Diagnosis, and Treatment. *https://pubmed.ncbi.nlm.nih.gov/28373987* **Langner S, Fleck S, Baldauf J *et al.* (2017):** Diagnosis and Differential Diagnosis of Hydrocephalus in Adults. *RoFo: Fortschritte Auf Dem Gebiete Der Rontgenstrahlen Und Der Nuklearmedizin*, *189*(8), 728–739.
2. **Pini L, Pievani M, Bocchetta M *et al.* (2016):** Brain atrophy in Alzheimer's Disease and aging. *Ageing Research Reviews*, *30*: 25–48.
3. **Richards E, Sanchez C, Phillips-Meek *et al.* (2016):** A database of age-appropriate average MRI templates. Neuroimage, 124: 1254-1259.
4. **Bidot S, Saindane M, Peragallo H *et al.* (2015).** Brain Imaging in Idiopathic Intracranial HypertensioN= *Journal of Neuro-Ophthalmology: The Official Journal of the North American Neuro-Ophthalmology Society*, *35*(4): 400–411.
5. **Labidi M, Lavoie P, Lapointe G *et al.* (2015):** Predicting success of endoscopic third ventriculostomy: validation of the ETV Success Score in a mixed population of adult and pediatric patients.
6. Journal of neurosurgery, 123(6):1447-1455.
7. **Dewan C, Lim J, Morgan D *et al.* (2016):** Endoscopic third ventriculostomy with choroid plexus cauterization outcome: Distinguishing success from failure. *Journal of Neurosurgery: Pediatrics*, *18*(6):655–662.
8. **Pindrik J, Rocque G, Arynchyna A *et al.* (2016):** Radiographic markers of clinical outcomes after endoscopic third ventriculostomy with choroid plexus cauterization: Cerebrospinal fluid turbulence and choroid plexus visualizatioN= *Journal of Neurosurgery: Pediatrics*, *18*(3): 287–295.
9. **Warf C (2005):** Comparison of endoscopic third ventriculostomy alone and combined with choroid plexus cauterization in infants younger than 1 year of age: A prospective study in 550 African childreN= *Journal of Neurosurgery*, *103*(6): 475–481.
10. **Kulkarni V, Warf C, Drake M *et al.* (2010).** Surgery for hydrocephalus in sub-Saharan Africa versus developed nations: A risk-adjusted comparison of outcome. *Child's Nervous System: ChNS: Official Journal of the International Society for Pediatric Neurosurgery*, *26*(12): 1711–1717.
11. **Shah H, LaFortune Y, Ibrahim M *et al.* (2020):** Endoscopic third ventriculostomy with choroid plexus cauterization for the treatment of infantile hydrocephalus in Haiti. *Journal of Neurosurgery: Pediatrics*, *25*(4):411–416.
12. **Warf C, Campbell W, Riddle E (2011):** Initial experience with combined endoscopic third ventriculostomy and choroid plexus cauterization for post-hemorrhagic hydrocephalus of prematurity: The importance of prepontine cistern status and the predictive value of FIESTA MRI imaging. *Child's Nervous System: ChNS: Official Journal of the International Society for Pediatric Neurosurgery*, *27*(7): 1063–1071.
13. **Dewan C, Naftel P (2017):** The Global Rise of Endoscopic Third Ventriculostomy with Choroid Plexus Cauterization in Pediatric Hydrocephalus. *Pediatric Neurosurgery*, *52*(6): 401–408.
14. **Santamarta D, Martin-Vallejo J, Díaz-Alvarez A *et al.* (2008):** Changes in ventricular size after endoscopic third ventriculostomy. *Acta Neurochirurgica*., *150*(2):119–127.