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Observations on the ventriculoperitoneal shunt vs endoscopic third ventriculostomy in management of hydrocephalus

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Abstract:

Background: A variety of medical specialists must provide hydrocephalus care for the rest of one's life. While acknowledged surgical alternatives for managing hydrocephalus, endoscopic third ventriculostomy (ETV) and ventriculo-peritoneal shunt (VPS) are controversial. In treating hydrocephalus, our goal was to evaluate the safety and effectiveness of ventriculoperitoneal (VP) shunt vs endoscopic third ventriculostomy (ETV). **Subjects and methods:** This Retrospective clinical study was conducted in the Neurosurgery Department at Helwan University Hospitals from January 2021 to January 2023. The participants were children (0–18 years) with obstructive/non-obstructive hydrocephalus caused by any etiology. This study included 56 cases that divided into two groups : group A was 28 and group B was 28. We found that the mean age of group A was 10.9 and 11 for group B. 60% of the group A were males and 65% of the group B. who underwent either ETV or VPS and the patients were followed up 3 months and 6 months. **Results:** The success rate between ETV 96.4% to VPS 70%. Length of stay for VP shunt was 4.1 ± 7 days and for ETV mean stay was 5 ± 3 days. there was less complication with the ETV in comparison to the VPS in many items. For example in infection its 7% in ETV vs 25% in VPS, and in obstruction its 3% for ETV vs 36% in VPS , but the rate of CFS leak in ETV is 21% vs 3% for VPS , and also the rate of Hemorrhage is 21% for ETV vs 7% for the VPS , and 46% of the ETV had no complication vs 29% of VPS. **Conclusion:** Endoscopic third ventriculostomy is effective and safe intervention for treatment of infantile hydrocephalus.

Keywords: Hydrocephalus, Endoscopic third ventriculostomy, ventriculo-peritoneal shunt

Introduction

A variety of medical specialists must provide hydrocephalus care for the rest of one's life. When caring for children with hydrocephalus, whether or not they have shunts, nonsurgical doctors frequently have concerns regarding shunt infection, dysfunction, and illness identification (**Chowdhury et al., 2017**).

Congenital hydrocephalus affects 0.5 to 1 out of every 1000 live births in developed nations, but acquired hydrocephalus affects 3 to 5 out of every 1000 live births (**Dewan et al., 2018**).

It is vital to first go over the formation, absorption, and route of Cerebrospinal Fluid (CSF) in order to fully comprehend hydrocephalus. Choroid plexus in the lateral, third, and fourth ventricles is primarily responsible for producing CSF. Capillaries and ependymal cells also have a small part in the secretion of CSF. CSF will flow into venous sinuses through arachnoid granulations, and subsequently through Virchow-Robin gaps to the lymphatic system. Subsequently, the majority of it will be emptied into the perineural space and into the craniospinal nerves, with a little portion going into the spinal cord (**Dewan et al., 2017**).

Hydrocephalus is caused by an imbalance in the generation and absorption of CSF or by blockage of the CSF flow channel. Ventricular dilatation results from this, raising intracranial pressure (ICP) (**Gholampour, 2018**).

Generally speaking, the volume of CSF is 160 mL, of which 25% circulates within the ventricles and 75% in the spinal and subarachnoid cortical regions (**Gholampour and Taher 2018**).

The typical CSF absorption rate in the spinal cord is 0.17 mL/min, while the mean±standard deviation (MSE) of CSF production is 0.34±0.13 mL/min. It should be noted that the CSF circulation has a fixed input and pulse under normal physiological conditions. The CSF pressure is the most significant hydrodynamic parameter indicating the occurrence of hydrocephalus (**Gholampour et al., 2017**).

Normal ICP levels for children, adults, and newborns under a year old are 3–4 mm Hg, 11 mm Hg, and 10–15 mm Hg, respectively (**Kang et al., 2017**).

The primary treatment for hydrocephalus is diversion of cerebrospinal fluid (CSF). Although there are a number of diversionary procedures, the ventriculoperitoneal shunt (VPS) is the most commonly used approach (**Langner et al., 2017**).

The recommended course of treatment for patients with communicating hydrocephalus is the implantation of a ventriculoperitoneal shunt (VPS), yet this technique has a significant failure rate—up to 40% within the first year and 50% within the second. Endoscopic Third Ventriculostomy (ETV), which is better suited for individuals with obstructive hydrocephalus, has long been thought to not function in this population (**Gholampour et al, 2019**).

VPS results, however, remain ambiguous due to the significant failure rate (25–36%) associated with shunts. ETV, a novel method for treating pediatric hydrocephalus, first appeared in the 20th century. Although this recently developed method yields encouraging results, certain investigations have shown that ETV also has a significant failure rate (**Li et al., 2017**).

There is disagreement over whether ETV or VPS is better for managing hydrocephalus. In the clinical etiologies examined, the effectiveness of VPS and ETV for pediatric hydrocephalus was shown to be comparable. However, the systematic review provides no explanation on the use of statistics in their study. For pediatric hydrocephalus, there isn't yet a meta-analysis on the most effective course of care (**Thompson 2017**).

Cine phase contrast magnetic resonance imaging is used to quantify a variety of CSF circulation parameters, including CSF flow velocity and flow rate diagrams for patients with hydrocephalus and

healthy participants (Cine PC-MRI). In the meantime, this apparatus is more beneficial for comprehending the pathophysiology of the patients. ICP monitoring, an invasive technique, can be used to measure ICP (Uche et al., 2018).

Aim of the work:

This study aimed to compare safety and efficacy of Endoscopic Third Ventriculostomy (ETV) versus ventriculoperitoneal (VP) shunt in the treatment of hydrocephalus.

Patients and Methods

This Retrospective clinical study was conducted at Helwan University Hospitals from January 2021 to January 2023. The Institutional Review Board at Helwan University granted approval. agreement from each patient to take part in the research. This study was carried out in accordance with the Declaration of Helsinki, which is the worldwide medical association's code of ethics for human subjects' research.

The inclusion criteria were children from 0-18 years, patients with communicating hydrocephalus who require CSF diversion surgery, as radiologically diagnosed (computed brain imaging techniques such as computed tomography or magnetic resonance imaging) in addition to clinical indications of elevated intracranial pressure. The standards for exclusion were bleeding within the brain's ventricles. the existence of two or more ventricular catheters, which suggests a lack of communication between the ventricles.

Methods:

Each patient underwent a thorough neurological examination, a thorough history collection, a full blood work-up, testing for liver function, blood urea and serum creatinine, random blood sugar readings, and urine analysis. The hydrocephalic alterations, size, degree of ventricular dilatation, and presence of calcifications were all visible on the CT image.

cystic or hemorrhagic areas, midline shift and cerebral edema. Also in all cases, CT scan was the principal follow up. A CT scan and magnetic resonance imaging (MRI) of the brain were requested in some cases to provide more accurate visualization of the ventricles and aqueduct of Sylvius and any pathology.

Surgical steps:

Burr hole was drilled; one 3 cm lateral to the midline and 1 cm anterior to the coronal suture, then opening the dura (dural flap) or linear incision. Coagulation of the arachnoid and pia. The endoscopic sheath with its trocar in place was introduced into the frontal horn. The trocar was then withdrawn, and in every instance—without the need for arm fixation—the rigid scope was inserted to view the ventricular system using a free-hand method. Following that, the endoscope was inserted into the third ventricle locating the foramen of Monro through identification of the choroid plexus, septal vein and thalamostriate vein.

The tuber cinereum, which is extremely thin and translucent, was determined to be the target for the fenestration after the third ventricle's floor was closely examined. The basilar artery is visible through the attenuated floor of the ventricle, and the floor was perforated using a fogarty catheter and a bipolar diathermy probe.

In some cases, a single large opening was done by dilatation of opening by fogarty catheter balloon either 3 F or 4 F in size. With continuous irrigation, there was free downward flow of CSF through the opening. To confirm patency of the stoma and flow of CSF to the basal cistern, flickering of the torn edges of the stoma done in the floor of the third ventricle after withdrawal of the endoscope tip for few

millimeters and stoppage of irrigation. The presence of flicker sign indicates good sufficient pulsatile CSF flow through the ventriculostomy opening and the third ventricle's floor mobility. In order to ensure that there is free connectivity between the prepontine cistern and the third ventricle, the endoscope was next pushed through the stoma parallel to the basilar artery. Any arachnoid bands or membranes that appeared to be preventing the CSF from flowing freely were forcefully broken.

Shunt procedure:

The aim of this procedure to remove the excess fluid from the ventricles.

To prevent hardware from laying directly under the skin incision, an inverted "C" shaped incision is made. This reduces the chance of skin breakdown and adds another layer of protection against subjacent hardware being infected. Although frontal burr holes (Kocher's point) are preferred by some due to a decreased failure rate from choroid plexus occlusion, posterior parietal burr holes are typically used for ventricular catheter insertion sites. At the time of implantation, CSF ought to be sent for culture. Peritoneal catheter: One of the recommended options is a horizontal incision made lateral and superior to the umbilicus. switching from a cranial incision to an abdominal one. connecting the shunt's components and securely fastening them with silk sutures while making sure the shunt is never constrained. To ensure that the shunt is functioning properly, CSF can flow from the distal limb of the shunt using a Medtronic medium pressure VPS. Tie the purse string suture after inserting the distal limb into the peritoneal cavity. layers of closure for the abdominal and scalp wounds.

Postoperative evaluation:

Patients was assessed clinically in the early postoperative period for seizures, motor deficit, sensory deficit, dysphasia and memory loss. Follow up for 3 months and 6 months and document outcome according to symptoms and head circumference.

ETV success score was done to all cases under went ETV pre operative to assess the benefit from the surgery and intraoperatively by seeing the CSF flow through its tract and predict the outcome, but in case of doubt of failure we used MRI flowmetry to see the patency of the CSF tract and localise the level of obstruction if existed.

We depended on Brain CT and abdominal US to assess the successful functioning VPS.

In case of infection post op. It is managed even by antibiotic according to culture and sensitivity or even by EVD until infection subsides.

Follow up: The patient followed by CT scan brain immediately after operation, 3 months and 6 months.

Statistical analysis

SPSS 20.0 for Windows (SPSS Inc., Chicago, IL, USA 2011) was used to gather, tabulate, and statistically analyze all of the data. The mean $\pm$ SD was used to convey quantitative data, while absolute frequencies (number) and relative frequencies (%) were used to express qualitative data. To compare two independently distributed, normally distributed variables, the t test was employed. When comparing percentages of categorical variables, the Fisher's exact test or the Chi-square test were used. The ordinal variables of the subjects were measured using the Frideman test at three or more time periods. Every test had two sides. Statistical significance (S) was defined as a p-value < 0.05 , while statistical insignificance (NS) was defined as a p-value ≥ 0.05 .

Results

Table (1): Demographic data

Patients' characteristics	ETV Group A N=28	VP shunt Group B N=28
Age (months)		
Mean $\pm$ SD	10.9 $\pm$ 4.7	11.0 $\pm$ 3.3
Gender		
Male no (%)	16 (60%)	18(65%)
Female no (%)	12(40%)	10 (35%)
Term of gestation		
Preterm	12 (18%)	7(15%)
Full term	16 (82%)	24(85%)

Table 1; showed that the study was conducted on 56 cases that split up into two groups, Group A (28 people) and Group B (28 people). We found that the mean age of group A was 10.9 months and 60% of them were males and group B was 11 months and 65% of them were males. 18% of group A were pre term while 15% of the group B were pre term also but most of our cases were full term by 80-85%.

Table (2): Etiology of hydrocephalus among the study population.

	ETV Group A N=28	VP shunt Group B N=28
Etiology of hydrocephalus		
Aqueductal stenosis	16(57%)	10(36%)
Arachnoid cyst in 4 th ventricle	3(11%)	7(25%)
Post infectious	2(7%)	5(18%)
Brain Tumour around aquiduct	7(25%)	1(3%)
Traumatic head injury	0(0%)	5(18%)

Table 2; showed that the etiology of hydrocephalus in group A , Most frequently, aqueductal stenosis was the reason by 57%, followed by brain tumours by 25%, Arachnoid cyst 11%, post infection 7%, and the least common cause is post traumatic 0% of cases. The etiology of hydrocephalus in group B, Additionally, aqueductal stenosis was the most frequent cause by 36%, followed by arachnoid cyst by 25%, post infection 18%, post traumatic 18% and the least common cause is brain tumours 3%.

Table (3): Clinical symptoms and signs

Symptoms	Percentage
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Delayed milestones	(4%)
Crying	(100%)
Fits	(14%)
Vomiting	(96%)
Altered conscious level	(25%)
Clinical findings	Percentage
Tense anterior fontanel	(93%)
Enlarged head circumference	(100%)
Sun setting eyes	(11%)
papilledema	(95%)

Table 3; showed that we found that: Symptoms were vomiting 96%, crying 100%, DCL 25%, fits 14%, delayed milestones 4%. Signs were enlarged head circumference 100%, sun setting appearance 11%, tense anterior fontanel 93% of cases, 95% had papilledema.

ETV success score: The ETVSS is calculated as Age Score + Etiology Score + Previous

Shunt Score covers the range of 0 to 90, and the value itself roughly represents the success rate of an ETV. Preoperatively, we assessed the ETVSS in every case, taking into account factors such as age, etiology, and prior shunt placement. We discovered that ETVSS accurately predicts the result.

Table 4; above shows the mean ETV success score 75.8 ± 6.3 . And this means that the cases that had high success score pre operative had good outcome according to the (ETV) group.

Table (4): Mean ETV success score

ETV success score	
Mean $\pm$ SD	75.8 $\pm$ 6.3

Table (5): Head circumference comparisons between the two groups on admission, after 3 months and 6 months.

Head circumference(cm) on admission	ETV Group A N=28	VP shunt Group B N=28
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Mean $\pm$ SD	47.18 $\pm$ 1.35	47.37 $\pm$ 1.58
Head circumference(cm) after 3 months		
Mean $\pm$ SD	45.24 $\pm$ 1.34	45.50 $\pm$ 1.67
Head circumference(cm) after 6 months		
Mean $\pm$ SD	45.17 $\pm$ 1.31	45.41 $\pm$ 1.84

Table 5 showed that the head circumference decreases over time of follow up, The difference between the two groups was comparable but it was insignificant.

Table (6): Clinical outcome among the study population

	ETV 28	VP shunt 28	P value*
Clinical outcome			
Successful	27 (96.4%)	20 (70%)	0.01*
Failure	1 (3.6%)	8 (30%)	

According to the clinical outcome there is significance between the success rate between ETV and VP shunt with percentage 96.4% for ETV to 70% for VPS as shown as in table 6.

Table (7): Operation time

Operation time (min)	ETV 28	VP shunt 28	P value*
Mean $\pm$ SD	68 $\pm$ 13	94 $\pm$ 20	0.03*
Length of Stay at Hospital (days)			
Mean $\pm$ SD	5 $\pm$ 3	4.1 $\pm$ 7	0.04*

And according to the operation time, table 7 there is significance between the operation time between both of them and the prevalence is to the ETV that reflects also on time of anesthesia and rate of infection and also on the hospital stay post operative.

Table (8): Clinical complications

Clinical complications	ETV 28	VP shunt 28	P value*
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Infection	2(7%)	7(25%)	<0.001**
CSF leak	6(21%)	1(3%)	<0.001**
Hemorrhage	6(21%)	2(7%)	0.021*
Obstruction	1(3%)	10(36%)	<0.001**
None	13(46%)	8(29%)	0.04*

Table 8; there was less complication with the ETV in comparison to the VPS in many items. For example in infection its 7% in ETV vs 25%in VPS, and in obstruction its 3% for ETV vs 36% in VPS , but the rate of CFS leak in ETV is 21% vs 3%for VPS , and also the rate of Hemorrhage is 21% for ETV vs 7% for the VPS , and 46% of the ETV had no complication vs 29% of VPS.

DISCUSSION

The study was conducted at Helwan University Hospitals on 56 cases that divided into two groups: group A(ETV) was 28 patient and group B (VPS) was 28 patient. We found that the mean age of group A was 10.9 months and 11 months for group B .60% of group A were males and 65% of group B were males . Regarding demographic statistics, there was no discernible difference between the two groups.

In our study, it was found that Aqueductal stenosis was the most frequent cause of the hydrocephalus etiology, which is (57% for group A and 36% for group B).

Similar to our results, **Alkhafaji & Hassan (2014)** reported that aqueductal stenosis is the most frequent cause of congenital obstructive hydrocephalus, as discovered in this study in 66.7% of individuals under the age of 12.

Also, **Lipina et al. (2008)** reported that Congenital aqueduct stenosis accounted for 35.7% of the etiology, followed by post-hemorrhagic (57.1%) and combined post-hemorrhagic and postinfection (7.1%).

Kulkarni et al. reported that the common etiologies including, Premature intraventricular bleeding (22.9%), aqueductal stenosis (21.2%), and posterior fossa cyst (7.6%) (**Kulkarni et al., 2018**).

As per the findings of the present research, **Shah et al.** reported that Dandy-Walker (13.4%), myelomeningocele (4.9%), aqueductal stenosis (29.3%), communicating hydrocephalus (15.9%), and intra-ventricular hemorrhage (1.2%) (**Shah et al., 2020**).

This study stated that the number of hydrocephalic children suffered from crying were statistically higher but other symptoms (delayed milestone, fits, vomiting and altered conscious level) between the two groups, there was no statistically significant difference. Furthermore, we

found tense anterior fontanelle signs were (93%), sun setting eyes was (11%), papilledema was (95%) and enlarged head circumference (100%).

Similarly , **Dewan et al.** reported that the most common presenting symptoms/signs of hydrocephalus were bulging fontanel (89%), enlarging head (77%), upgaze palsy/paresis (17%), and delayed milestone and irritability (1%) (**Dewan et al., 2018**).

In a study of **Dewan et al.** regarding According to the clinical signs and symptoms, 36 patients (82%) had a head circumference that was gradually rising at presentation, 40 patients (91%) had a bulging fontanel, and 4 patients (9%), had ocular palsy associated with hydrocephalus (**Dewan et al., 2016**).

Kulkarni et al. reported that the common presenting signs and symptoms were increased head circumference (68.5%), splayed sutures (51.7%), upgaze palsy (6.8%), vomiting and agitation (5.9%), bradycardia or apnea (3.4%), bulging fontanelle (66.9%), and CSF leak (0.8%) (**Kulkarni et al., 2018**).

Mousa et al. were consistent with the current findings since they stated that, upon clinical examination, seven patients (21.8%), including five (15.6%) with papilledema and two (6.2%) with papilledema and sixth cranial nerve palsy, presented only symptoms of elevated ICP at the time of presentation. Two patients (6.2%) were completely free on neurological examination, and seven patients (21.8%) solely showed posterior fossa signs (cerebellar ataxia and long tract indications, primarily weakness). Sixteen patients (50%) showed evidence of both. (**Mousa et al., 2017**).

According to our research, the average ETV success score was 75.8 ± 6.3 . Furthermore, the accomplishment rate was 79% in ETV group and 70% in VP shunt.

A recent study reported that the median ETV success score was 50. Successful ETV was performed in 86.6% of patients (n = 71) (**Shah et al., 2020**).

Another According to a prior study, Uganda's mean percentage of EVT success was 37.9%, while industrialized countries' percentage was 57.4% (**Kulkarni et al., 2010**).

The difference between the two groups was comparable but it was insignificant as regards head circumference after 3 months and 6 months.

Hasanin et al (2020) who aimed to evaluate the relationship between clinical improvement and volumetric alterations in the brain ventricles following a successful ventriculoperitoneal (VP) shunt operation. During the 6-month postoperative follow-up period, there was a noticeable improvement in head circumference, with values ranging from 32 cm at its lowest value to 42 cm.

In this study, the infection rate and blockage rate were statistically significant higher in VP shunt group than the ETV group. This could be explained by the fact that, in contrast to ETV

surgery, VP shunt operations need a large operative area and the use of implantable devices (**Simon et al., 2014**).

Another meta-analysis by **Jiang (2018)** discovered that, in comparison to VP shunt, ETV had a reduced risk of complications, infections, and reoperations, as well as a shorter surgical and hospital stay duration. However, it displayed comparable outcomes in terms of the incidence of symptom improvement, hematoma, and mortality.

In the same line with our findings, **Abdel-Aziz et al.** stated that because ETV is linked to a lower rate of postoperative infection and a shorter operation duration, it is preferable than VPS. (**Abdel-Aziz et al., 2020**).

Furthermore, the shunt obstruction may be explained by the high protein content of CSF cells, which promotes easy sediment accumulation. Furthermore, cell damage to the intraventricular choroid plexus may result in a build-up of cell debris on the shunt tube, which may clog it later. Moreover, the blockage may be caused by the larger omentum of pseudocyst around the peritoneal end (**Reddy et al., 2014**).

However, the study of had a little greater frequency of shunt infection and exposure **Alkhafaji & Hassan (2014)** (26%) as opposed to 11.1% in the preceding one. In their series, the overall revision rate for V-P shunt was 20 patients (30.3%), which is less than the findings of **Borgbjerg-BM, et al** who has out a retrospective analysis on 884 patients with hydrocephalus of different causes, finding that 38.5% of those patients had their ventriculo-peritoneal shunt revised.

Lu et al. (2019) When compared to VPS, ETV significantly lowers the overall rate of postoperative complications and mortality, according to their meta analysis of randomized controlled studies. They continued by saying that even though VPS is widely used to treat hydrocephalus, it is linked to a greater infection rate (26 instances) in all included studies as opposed to only one case in the ETV group, which was substantially different. Furthermore, a higher risk of infection and sepsis in the VP shunt group led to a significantly higher fatality rate. **Abdel-Aziz (2020)** reported that Postoperative infection rates in the ETV group were 23.1% versus 53.8% ($P = 0.045$), which was statistically significant less than in the V-P shunt group. Regarding the rate of obstruction, there was no statistically significant difference between the two research groups.

Conclusion

Infantile hydrocephalus can be effectively and safely treated with endoscopic third ventriculostomy. Given that it is linked to a reduced rate of postoperative infection, a shorter duration of surgery and hospital stay, and positive results, it is preferable to the VP shunt.

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