Endoscopic Third Ventriculostomy with or without Choroid Plexus Cauterization

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

Abstract:

Background: Endoscopic third ventriculostomy (ETV) with or without choroid plexus cautrization (CPC) has been suggested as the ideal treatment for some instances of paediatric hydrocephalus because of the reported rise in shunt failure rates in our country. The outcomes are unclear since surgical hydrocephalus management is not a common practice in our nation. This finding led to the investigation of the efficacy of ETV alone and in combination with CPC as a main therapy for pediatric hydrocephalus.**The aim of review was** to evaluate outcome of the Endoscopic Third Ventriculostomy (ETV) and ETV-CPC procedures as surgical options for selected forms of hydrocephalus.**Conclusions:**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. Given the lack of access to neurosurgical care in this country, ETV/CPC is likely to remain a mainstay in the treatment of infant hydrocephalus. Among the causes of noncommunicating hydrocephalus, aqueductal stenosis remains one of the most common in our study.

Keywords: Choroid Pleuxus Cauterization, Hydrocephalus, and Endoscopic Third Ventriculostomy.
DOI Number: 10.48047/nq.2022.20.19.NQ99095 **NeuroQuantology2022;20(19): 1044-1055**

Introduction:

The father of neuroendoscopy is commonly acknowledged as being Walter Dandy. He explained an endoscopic method of doing a choroid plexectomy to treat hydrocephalus. By executing a craniotomy fenestration in the lamina terminalis in 1922, Dandy also invented the idea of a ventriculostomy, however William Mixter is credited with completing the first successful endoscopic ventriculostomy (1). A 9-year-old girl with noncommunicating hydrocephalus underwent ventriculography and ventriculostomy in 1923 by Mixter using aureteroscope. Endoscopes for ventricular surgery were created by Tracy Putnam and John Scarff, respectively. Scarff made many changes to the design, including angling the view, incorporating a continuous watering system to replace the CSF, and introducing a portable unipolar electrode (2).

In the 1950s, CSF diversion techniques were routinely utilized. The high mortality and morbidity rates associated with endoscopic procedures, together with technological challenges, were the driving forces behind the shunt surgeries that took place at this time. Despite improvements in shunt technology, problems including infection and malfunction were always a possibility with CSF diversion. Following the development of shunting systems in the 1950s, ETV went out of favor until making data up until 1970. He used a ventriculoscope to describe bilateral CPC without draining CSF, much like Putnam did. The cortex was prevented from collapsing by keeping the ventricle fluid-filled, which "enormously decreased surgical shock and consequent mortality." Scarff thought that the key to success was to cauterize as severely as possible (3).

New Technologies:

The rebirth of interest in ventriculostomy as a viable alternative therapeutic approach is mostly attributable to the development of a new tool known as neuroendoscopy, or simply endoscopy. During neuroendoscopy, a tiny viewing scope is introduced into the third ventricle to project pictures onto a monitor next to the operating table. As a result, the neurosurgeon may see the ventricular system within during operation (5). Typically, a small hole is made through the skull to introduce the endoscopic catheter. In patients who already have shunts, the neurosurgeon may be able to exploit the initial bone defect made when the shunt catheter was first inserted. Therefore, only a tiny hole in the skull is required for endoscopic third ventriculostomy; additional brain exposure is not required.

Important landmarks:

For an effective ETV, it is essential to identify key ventricular landmarks and structures. Because its anterior portion spreads to the foramen of Monro and then to the third ventricle, the choroid plexus is a significant anatomical marker in the lateral ventricle. The surgeon has a route to the third ventricle after identifying the choroid plexus in the lateral ventricle.

The choroid plexus is still present at the choroidal fissure despite severe

a comeback in the 1970s and 1980s. At the end of the 1970s, interest in minimally invasive surgery increased as a result of developments in neuroimaging, stereotaxis, illumination, and computer technology. Obstructive hydrocephalus and a number of other disorders are now often treated by endoscopic third ventriculostomy(1).

Victor Darwin Lespinasse, a urologist from Chicago, carried out the first cauterizations of the choroid plexus (CP) over a century ago. He entered the ventricles of two newborns with a tiny cystoscope and cauterized bilateral CP there. While one patient passed away, another lived for an additional 5 years. He described the treatments to his doctor daughter as a "intern's trick" (3). Fourhydrocephalus patients, including children, who had choroid plexotomies were documented by Walter Dandy. He spoke of surgically excising the CP after entirely emptying the ventricles, but the collapse of the thinner ventricular walls resulted in life-threatening shock. Three of the four patients passed away within four weeks following their procedures. Dandy described utilizing a Kelly cystoscope to reach each lateral ventricle after CSF draining. CP avulsion and/or cauterization are further treatments. A device that enables operations inside the ventricular system is known as a "ventriculoscope" (2). Others saw the promise of ventriculoscopic CPC despite Dandy's high fatality rates and strove to make it secure. In order to reduce CSF loss, Tracy Putnam performed bilateral endoscopic CPC in 1934. He documented his experience conducting the surgery on 42 youngsters even if the results weren't great (4). John Scarff, a former Dandy trainee, reported performing CPC using a self-modified ventriculoscope in 1936 and continued to publish long-term outcome third ventricle's lateral walls. The floor is bordered anteriorly by the infundibular recess, laterally by the walls of the third ventricle, and posteriorly by the mammillary bodies. A safe area slightly anterior to the midpoint between the infundibular recess and the mammillary bodies is where the third ventricle perforation is typically performed. If penetrating farther posteriorly, you can reach the basilar tip and anterior clivus (7).

Technique:

Patient Positioning:

The patient should be lying on their back with their head slightly flexed (15°), yet firmly secured. A horseshoe headframe is adequate until astereotactic or neuronavigation procedures are necessary, in which case a specialised stereotactic frame or three-point Mayfield headframe is needed (7). in Figure 1.

ventricular architecture deformities, and it is a crucial surgical navigational aid (7). The fornix, which makes up the superior and anterior edges of the foramen of Monro, is another important anatomical feature. Because of where it is when an endoscope is moved from the lateral to the third ventricle, the fornix is susceptible to harm. Increasing the number of passages.thus does the danger of harm. Another important landmark is the thalamostriate vein, which runs from the choroid plexus to the foramen of Monro (8).

The third ventricle's lateral walls are built by the hypothalamus. Due to their positioning in the lateral wall and closeness to the trajectory, the supraoptic and paraventriculararcuate nuclei are the structures that are most susceptible to damage during an ETV. Damage to these nuclei can cause serious endocrinologic issues since they generate vasopressin and oxytocin (9).

The third ventricular floor is simply a narrow section of the hypothalamus that is sandwiched between two of its sections in the

Figure (1): The patient in a supine position under general anaesthesia, prepared for the endoscopical approach In any case, secure fixation of the head should be ensured. The monitor should be placed in front of the surgeon to allow him to operate with his head in a neutral position(9).

Skin Incision:

A 5-cm skin incision is usually sufficient. Always clip hair in a narrow, 5 cm to 1 cm wide strip on the parasagittal line that crosses the midpupillary spot. The coronal suture should be cut 2 centimeters behind and 3 centimeters in advance of the incision (figure 2,3). which, depending on where the burr hole is, may typically be felt (1).

Figure (2): Land mark of skin incision and site of entery point

Figure (3): Intraoperative picture showing the drilled burr hole; 10 mm in diameter; one cm anterior to coronal suture and 3 cm lateral to midline

On the lateral corner of the bregmatic fontanel, half in front and half behind the coronal suture, is where the skin incision in newborns should be made. Making a longer incision is typically preferred because, in newborns, a wider bone hole is needed to allow for the dura's watertight closure when the endoscope is removed (7).

Burr Hole:

After the skin is incised, the coronal suture should always be visible, and the burr hole should be 0.5 cm in front of it (figure 4). Numerous researchers found that the burr hole was often located 1-2 cm anterior to the coronal suture and less than 3 cm laterally to the midline (8). A certain amount of variance is always conceivable due to the cephalocranial parts' individual variability (1).

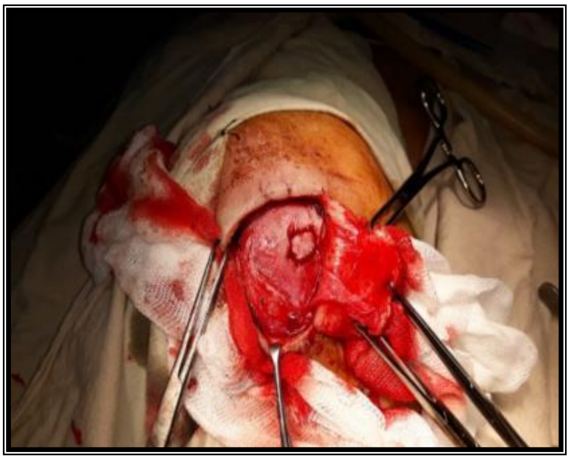

Figure (4): Intraoperative picture showing the drilled burr hole; 10 mm in diameter; one cm anterior to coronal suture and 3 cm lateral to midline.

A burr hole that is too far anterior could result in an incorrect trajectory with an excessive anteroposterior inclination through the foramen of Monro, whereas one that is too far posterior could damage the pyramidal tract. The anterior column of the fornix may sustain structural damage in any effort to alter its trajectory after passing through the foramen of Monro. The burr hole needs to be big enough for an endoscope to fit through and be manipulated.

Ventricular Entry and Navigation:

Many writers recommend using ventricular tapping to locate the ventricle and make a tiny hole in the ependyma so the endoscope trocar may pass through it. In the event of tiny ventricles, such as those produced by shunt dysfunction, this surgery is undoubtedly appropriate. The ventricles are often quite big and simple to find utilizing a specially constructed peel away sheath during first operations on youngsters (9).

Irrigation:

If the ventricular tapping was performed perfectly, there should be no bleeding seen in the intraventricular CSF after the endoscope was placed. A tiny ependymal vein on the ventricular roof that was ruptured by the endoscope during ventricular entry, or little venous bleeding from behind the light source, which typically begins within the endoscope track and descends into the ventricle surrounding the trocar, is not unusual (1). If bleeding develops, it should be stopped using intraventricular irrigation before the situation becomes much worse—possibly before it reaches the third ventricle. The most popular fluid at body temperature (36°C) is ringer's lactate, but 0.9% saline solution can also be used (10).

Floor Perforation:

The architecture of the third ventricle should be thoroughly inspected with the endoscope before attempting to puncture the floor. The mamillary bodies are the earliest discernible structure, followed by the infundibular recess (figure 5,6). Between these two structures, the third ventricle's floor is visible as a translucent membrane with the general shape of an irregular rhomboid, with the larger triangle with the apex anterior at the level of the dark spot identifying the infundibular recess and the smaller triangle with the apex posterior included between the two mamillary bodies (8).

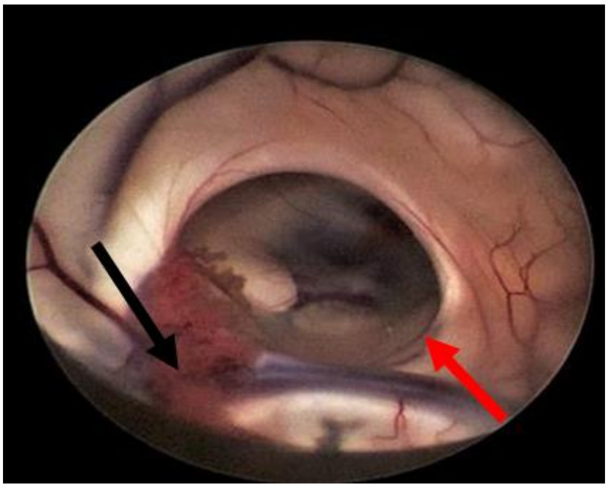

Figure (5): Endoscopic view of the foramen of Monro. The red arrow is on the fornix and pointing to the foramen of Monro. The black arrow head points to the choroid plexus in the lateral ventricle entering the foramen.

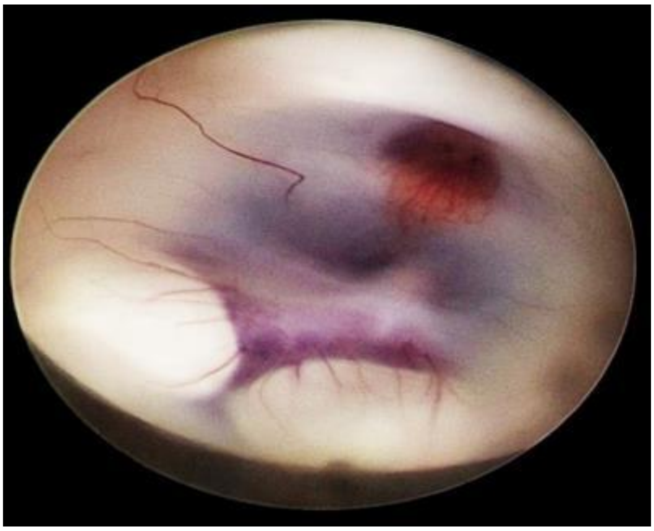

Figure (6): Endoscopic view of the floor of third ventricle. The structures seen are the mammillary bodies and rounded depression is infundibulum located at the base of the pituitary stalk.

The middle of the second triangle's height is where the perforation should be made. Of course, this rule needs to be modified to account for the variations in anatomy that may occur. The basilar artery or the perforating vessels coursing to the ventral aspect of the mesencephalon would be at risk of injury if the perforation were to be performed behind the mamillary bodies; even if the perforation itself were to be uneventful in this location, inflation of the balloon for stoma dilation would tear these perforating vessels, with disastrous results (figure 7). (9).

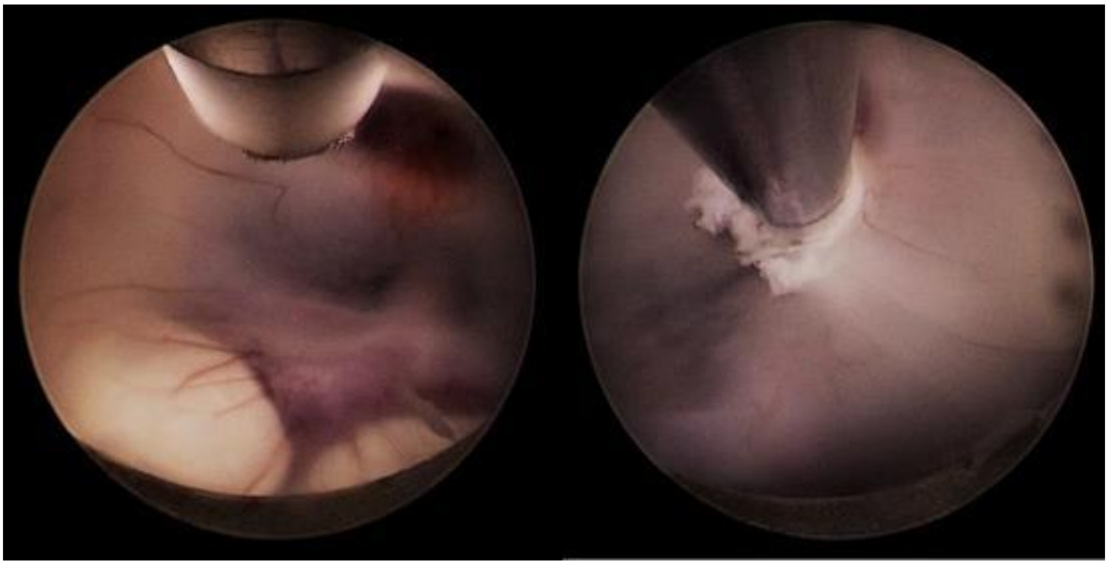

Figure (7): Perforation of the floor of third ventricle by ventriculostomy bipolar.

Dilatation of the Stoma:

The most popular method of ventriculostomy is balloon dilatation, which dilates the stoma. The surgeon makes an opening in the floor using the endoscope's working channel by using a blunt dissector or a blunt monopolar coagulator tip. A French balloon (Fogarty 3 or 4) is then passed through the first fenestration after the dissector has been pulled. The balloon is gradually inflated within the fenestration to increase the aperture (figure 8,9). (7).

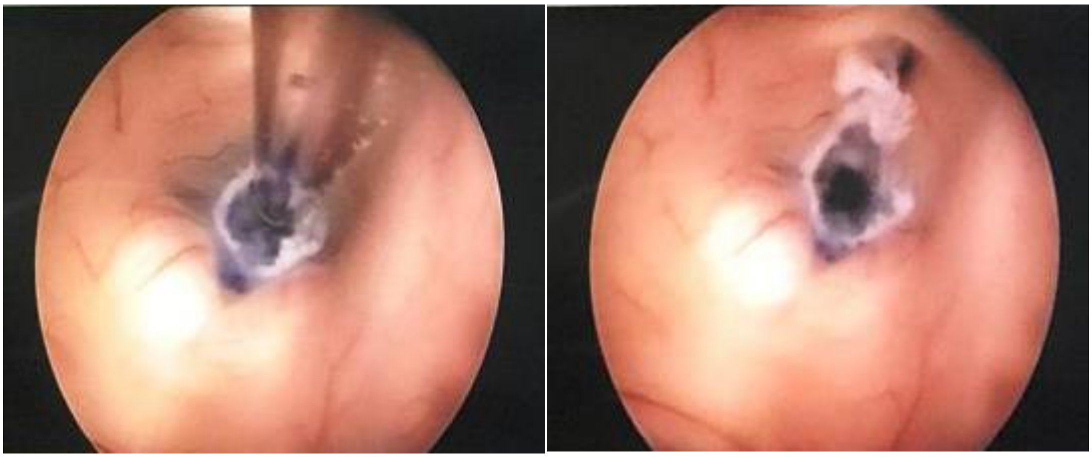

Figure (8): Dilatation of ostium with Fogarty catheter balloon 3F size.

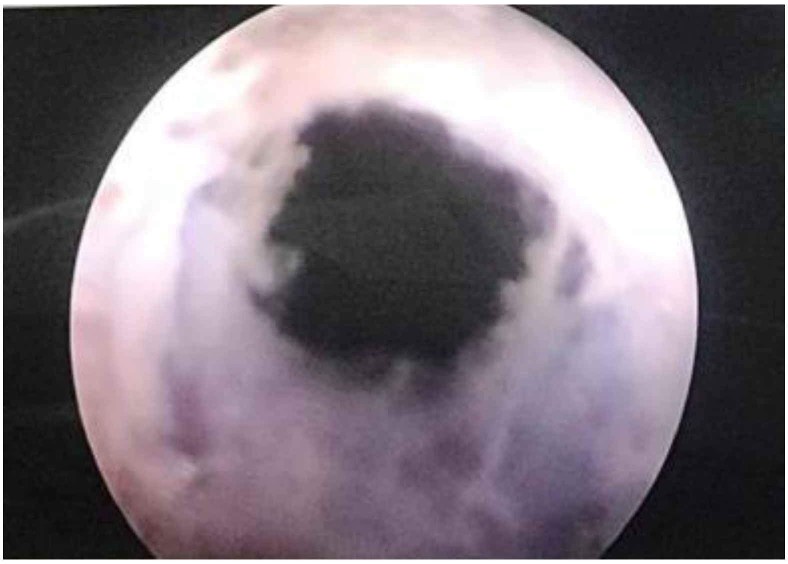

Figure (9): Ostium after dilatation.

The balloon is then pushed back and deflated. This method has several benefits, including the ability to safely perform it multiple times, the ability to see the ventricle floor and even the prepontine cistern during balloon inflation, and the ability to use balloon inflation as a hemostatic tool in the event of capillary bleeding from the floor. The endoscope should be advanced following fenestration in order to visualize arachnoid strips and the Liliequist membrane. These advantages make balloon dilatation the safest fenestration method (2).

There are several methods that may be utilized to puncture the third ventricle's floor. The most basic method is fenestration through the endoscope's tip. The success of this method was shown in several programs. This strategy does have some drawbacks, though. A steep learning curve, a tiny diameter endoscope, and visual obstruction during floor dissection are all desirable. There are other additional methods, such as the saline torch and laser energy, although it is unclear how safe and effective these are (7).

Opening of Liliequist's Membrane:

Following perforation and stoma dilatation, the floor membrane starts to pulse and move in time with the heartbeat. Insert the endoscope into the subarachnoid space to look for signs of connection between the third ventricle and the area (7). The basilar artery and/or its branches, the ventral surface of the brainstem, the third cranial nerve, and the clivusdura should all be clearly apparent anatomical features of the interpeduncular or prepontine cistern. Due to Liliequist's membrane, it is frequently hard to visualize these structures (2).

Closure:

The endoscope can be carefully removed from the ventricular cavity after establishing adequate connectivity between the third ventricle and the subarachnoid areas through a sizable aperture (at least 4 mm). By irrigation with Ringer's lactate at body temperature or by inflating and keeping the balloon within the stoma for 40–50 seconds, small-scale bleeding at the stoma's borders can be quickly stopped (9). The endoscope should be withdrawn extremely gently via the white matter route to prevent intraparenchymal hemorrhage, which may result in the uncommon intraparenchymal hematoma along the endoscope track (10).

ETV with CPC:

ETV is advised as the initial procedure because CPC-related hemorrhage may make it impossible to safely see the floor of the third ventricle. Choroid plexus cauterization (CPC) has reemerged in recent years as an additional therapy method used in combination with ETV (figure 10). CPC increases the likelihood of treating certain babies with hydrocephalus effectively when compared to ETV alone. The principal source of CSF secretion within the brain is thought to be removed as part of the therapy. ETV may operate as a pulsation absorber to lessen intraventricular pulsations, which may enhance CSF pulsatility, which CPC may diminish. The sum of these effects may, in certain cases, tilt the scales in favor of CSF absorption and render shunting unnecessary (3).

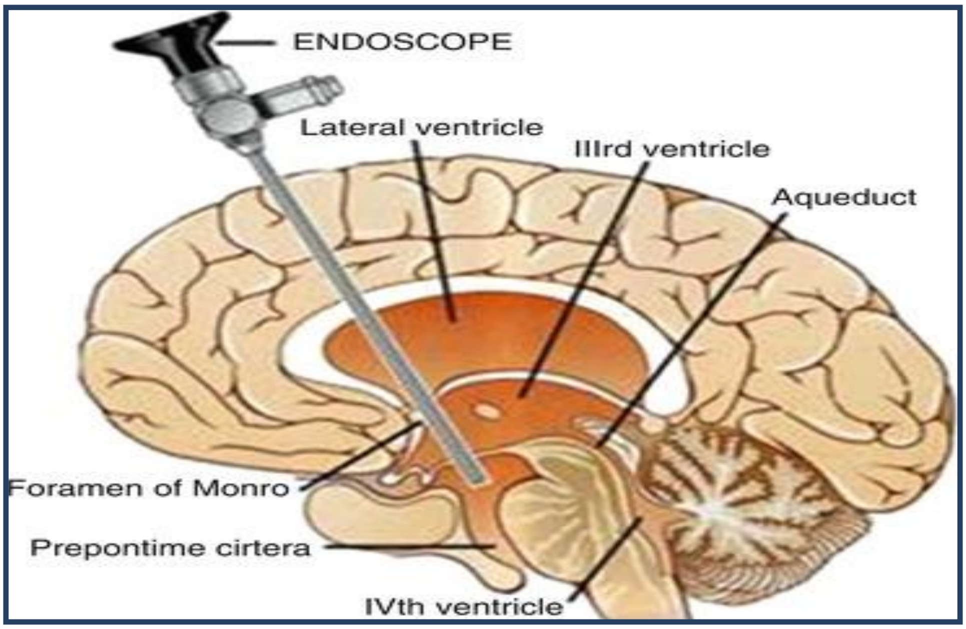

Figure (10): Endoscopic Management of Hydrocephalus and Choroid Plexus Cauterization [8].

individual should be over six months old).

2. A diagnosis of non-communicating hydrocephalus (obstructive ventricular channels) (5).

The presence of a previous shunt may have allowed the subarachnoid spaces around the brain to expand, and the patient may have had more time to acquire absorption skills due to the working shunt. But it's crucial to remember that, in cases when people have been shunted for a while, it's sometimes hard to tell whether the hydrocephalus is communicating or not without intrusive testing (6).

Aqueductal stenosis is the most prevalent cause of congenital hydrocephalus, and some writers claim that individuals with this condition have a greater success rate. Aqueductal stenosis develops when fluid builds up upstream of the blockage in the lengthy, confined tube connecting the third and fourth ventricles, leading it to become obstructed. Ventricular width (at least 7 millimeters), the absence of prior radiation therapy, and a thin third ventricular floor are additional factors influencing the success of an endoscopic third ventriculostomy.

Outcomes:

In this surgery, "success" is commonly defined as preventing the need for a shunt in a patient who would otherwise need one (by both patients and doctors). The majority of medical professionals deem an endoscopic third ventriculostomy effective if the patient afterwards displays structurally stable or reduced ventricular size as well as clinical signs of normal intracranial pressure (ICP). If a patient has previously undergone shunt surgery, the procedure must be

Rationale:

Despite the fact that open ventriculostomies were performed as early as 1922, shunt devices made them less popular in the 1960s. Despite recent advancements in surgical and shunt technologies, shunts are still frequently inadequate (12). Extracranial shunts in particular are prone to issues including obstruction, infection, and overdrainage that call for several surgical modifications. As a result, neurosurgeons may advise endoscopic third ventriculostomy rather than shunting(13).

The ultimate objective of an endoscopic third ventriculostomy is to do away with the requirement for a shunt. Although endoscopic third ventriculostomy is meant to be a one-time surgery, data indicates that some individuals may need further operations to maintain appropriate opening and drainage (12). ETV/CPC became the preferred method of therapy for baby hydrocephalus when resources were scarce. Benjamin Warf observed that adding CPC to ETV raised hydrocephalus treatment success rates from 47 to 66% in a large cohort of 1-year-old babies with diverse etiologies (3).

Cases with a non-infectious condition, especially hydrocephalus linked to myelomeningocele, had a higher chance of responding well to CPC. Using ETV/CPC for a variety of conditions led to higher success rates, according to additional research, which included a randomised controlled trial.

Patient preference:

Most medical professionals and contemporary research attribute two things to the effectiveness of ventriculostomies:

1. Age (the subject must be older than six months) (the

the ventricular system, high-resolution MRI allows medical professionals to observe the absence of flow via a stenosed or blocked aqueduct (13).

Fever and bleeding are the most frequent side effects of an endoscopic third ventriculostomy. The employment of a cold light source with monopolar coagulation can increase CSF temperatures to riskily high levels, sometimes leading to fever, in the constrained volume of the third ventricle. Bleeding may be caused by attempts to puncture the ventricular floor, ventricular wall injury, or perforation of the basilar artery. Large bleeding from artery damage below the third ventricle are unusual but can be lethal (6).

Short-term memory loss is another potential side effect of endoscopic third ventriculostomy since the surgery may have an impact on the hypothalamus and mamillary body regions that are involved in memory. However, most individuals gradually regain any short-term memory loss brought on by an endoscopic third ventriculostomy (8).

Endocrinologicdysfunction may develop during endoscopicthird ventriculostomy because the region of the third ventricle where the opening is established is important for certain hormone activity. Usually, this difficulty will pass. Another brief consequence is diabetes insipidus (13).

The risk profile for ETV/CPC was minimal, with rates of adverse events and death being 3.7% and 0.4%, respectively. As cauterization continues, CP hemorrhage is common. Usually, irrigation is sufficient to keep hemostatic balance (3). Although it is quite unlikely (0.21%), an inadvertent major vascular damage that causes serious bleeding is a possibility. The risk of infection is significantly reduced with ETV/CPC successful if the shunt is removed or can no longer function (13).

Most medical professionals see an endoscopic third ventriculostomy as a failure if a patient's clinical symptoms, ventricular enlargement, or need for a shunt develops within days or months following the surgery (5). Measurements of the head circumference, fontanelle tension, clinical symptoms of elevated intracranial pressure, and CT or MRI images are used to predict the success of an endoscopic third ventriculostomy. It's crucial to remember that ventricles can continue to grow even after normal intracranial pressure has been restored (8).

Getting rid of the shunt is frequently cited as a crucial aspect of "success," however numbers from the present might not be entirely accurate. In fact, it has been claimed by a number of writers that even if a ventriculostomy "failed," the shunt that results from it could still be simpler to maintain. However, more study and debate are needed in this area. In addition, success might not be known right once since CSF reabsorption routes need time to adapt to the larger volumes of CSF following ventriculostomy (6).

Most patients with unsuccessful ventriculostomies will continue to be shunt-dependent. The inability of the arachnoid villi to absorb extra CSF or an obstruction in the subarachnoid channels directing CSF to the arachnoid villi is cited as causes of procedure failure (5).

Due to modern technology including magnetic resonance imaging (MRI), stereotactic guided endoscopy, flexible fiber optic scopes, and enhanced manipulation and hemostasis instruments, endoscopic third ventriculostomy risks have decreased. While neuroendoscopic treatments offer previously unattainable views from within insertion than with VPS insertion since artificial implants are not required. Assuring multi-layered wound closure is a crucial technical aspect of infant ventricular endoscopy in order to prevent CSF leakage, which occurs at a rate of 5%.

Several factors might cause ETV/CPC to fail. To begin with, even if the treatment is carried out successfully, it might not be enough to stop the progression of decompensated hydrocephalus. Additionally, the ETV stoma may get blocked. According to certain data, it may be possible to redo ETV before deciding to install a shunt. Children who got concurrent CPC, with post-infectious aetiology and a longer period after first failure may do better following repeat ETV (3).

Conclusions:

For newborns with hydrocephalus, the combination of ETV and CPC may enhance outcomes. ETV/CPC continues to be a workable, successful treatment for lessening the need for VPS in Egypt with a low but considerable risk profile. ETV/CPC is expected to continue to be a cornerstone in the management of baby hydrocephalus given the paucity of access to neurosurgical care in this nation. Aqueductal stenosis continues to be one of the most frequent causes of noncommunicating hydrocephalus in our study.

References:

1. **Unal, T. C., &Aydoseli, A.** Endoscopic Third Ventriculostomy. In Hydrocephalus-Water on the Brain. IntechOpen.2018.
2. **Schmitt, P. J., & Jane, J. A.** A lesson in history: the evolution of endoscopic third ventriculostomy. Neurosurgical Focus, 2012:33(2), E11.
3. **Coulter, I. C., Dewan, M. C., Tailor, J., Ibrahim, G. M., &Kulkarni, A. V.** Endoscopic third ventriculostomy and Choroid plexus cauterization (ETV/CPC) for hydrocephalus of infancy: A technical review. Child's Nervous System,2021: 37(11), 3509-3519.
4. **Kulkarni, A. V., Riva-Cambrin, J., Holubkov, R., Browd, S. R., Cochrane, D. D., Drake, J. M., ... &Kestle, J. R.** Endoscopic third ventriculostomy in children: prospective, multicenter results from the Hydrocephalus Clinical Research Network. Journal of Neurosurgery: Pediatrics,2016: 18(4), 423-429.
5. **Kulkarni, A. V., Riva-Cambrin, J., Rozzelle, C. J., Naftel, R. P., Alvey, J. S., Reeder, R. W., Holubkov, R., Browd, S. R., Cochrane, D. D., Limbrick, D. D., Simon, T. D., Tamber, M., Wellons, J. C., Whitehead, W. E., &Kestle, J. R. W.** Endoscopic third ventriculostomy and choroid plexus cauterization in infant hydrocephalus: A prospective study by the Hydrocephalus Clinical Research Network. *Journal of Neurosurgery: Pediatrics*,2018: *21*(3), 214–223.
6. **Ellenbogen, Y., Brar, K., Yang, K., Lee, Y., & Ajani, O.** Comparison of endoscopic third ventriculostomy with or without choroid plexus cauterization in pediatric hydrocephalus: a systematic review and meta-analysis. Journal of Neurosurgery: Pediatrics, 2020:26(4), 371-378.
7. **Tamburrini, G.** Endoscopic Third Ventriculostomy: Technique. Textbook of Pediatric Neurosurgery,2020: 755-765.
8. **Oluigbo, C., & Keating, R.** Endoscopic management of hydrocephalus and

choroid plexus cauterization. In Hydrocephalus (pp. 201-208). Springer,2017: Cham.

9. **Yadav, Y. R., Parihar, V., Pande, S., Namdev, H., &Agarwal, M.** Endoscopic third ventriculostomy. Journal of neurosciences in rural practice, 2012:3(02), 163-173.
10. **Dewan, M. C., Lim, J., Morgan, C. D., Gannon, S. R., Shannon, C. N., Wellons, J. C., &Naftel, R. P.** Endoscopic third ventriculostomy with choroid plexus cauterization outcome: Distinguishing success from failure. *Journal of Neurosurgery: Pediatrics*,2016: *18*(6), 655–662. https://doi.org/10.3171/ 2016.6.PEDS1675
11. **Jallo, G. I., Kothbauer, K. F., & Abbott, I. R. (2005).** Endoscopic third ventriculostomy. Neurosurgical focus, 19(6), 1-4.
12. **Bankole, O. B., Ojo, O. A., Nnadi, M. N., Kanu, O. O., & Olatosi, J. O.** Early outcome of combined endoscopic third ventriculostomy and choroid plexus cauterization in childhood hydrocephalus. Journal of Neurosurgery: Pediatrics, 2015:15(5), 524-528.
13. **Omar, A. T., Espiritu, A. I., & Spears, J.** Endoscopic third ventriculostomy with or without choroid plexus coagulation for myelomeningocele-associated hydrocephalus: systematic review and meta-analysis. Journal of Neurosurgery: Pediatrics, 2022:1(aop), 1-9.