Endoscopic Third Ventriculostomy: Indications, Surgical Technique, And Potential Problems

Endoskopik Üçüncü Ventrikülostomi: Endikasyon, Cerrahi Teknik ve Potansiyel Problemler

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Abstract: Endoscopic third ventriculostomy is becoming more popular as an alternative to shunting in the management of obstructive-type hydrocephalus. The goal of this procedure is to fenestrate the floor of the third ventricle between the mamillary bodies and the infundibular recess, and thus establish flow of cerebrospinal fluid between the ventricles and the basal subarachnoid spaces. Obstructive hydrocephalus is the main indication for endoscopic third ventriculostomy, but this procedure is also currently used to treat a wide range of hydrocephalic patients. In this surgical technique, various anatomic variations and technical difficulties can lead to complications. However, in cases where this procedure is indicated, good knowledge of third ventricle anatomy and experience with endoscopic surgery can yield success rates of up to 80%.

Key Words: Hydrocephalus, neuroendoscopy, third ventricle, ventriculostomy

Özet: Endoskopik Üçüncü Ventrikülostomi obstrüktif tip hidrosefali tedavisinde son yıllarda giderek artan bir ilgiyle şanta alternatif olarak kullanılmaktadır. Endoskopik üçüncü ventrikülostomide amaç üçüncü ventrikül tabanında mamiller cisimcikler ve infundibüler reses arasında bir fenestrasyon oluşturmak ve ventriküler sistem ile basal subaraknoid aralıklar arasında serbest BOS dolanım ve emilimini sağlamaktır. Esas olarak obstrüktif tip hidrosefali vakalarında endike ise de günümüzde daha geniş bir hasta grubunda kullanılmaktadır. Bu cerrahi teknikte bazı anatomik varyasyonlar ve potansiyel teknik güçlükler komplikasyonlara neden olabilmektedir. Bununla beraber doğru endikasyon, konan vakalarda yeterli ventrikül içi anatomi bilgisi ve endoskopik cerrahi tecrübesi ile %80 oranlarında başarı elde edilebilmektedir.

Anahtar Kelimeler: Hidrosefali, üçüncü ventrikül, nöroendoskopi, ventrikülostomi,

INTRODUCTION

The past decade has witnessed a resurgence of endoscopic third ventriculostomy in neurosurgery. Dandy was the first to do a third ventriculostomy in a patient in 1922 and a year later, in 1923, Mixter carried out the first endoscopic procedure in neurosurgery using a small ureteroscope and performing a third ventriculostomy procedure endoscopically (5,11). In the pre-shunt era, this procedure was one of the most frequently performed surgical procedures in the management of hydrocephalus. However, due to high complication and mortality rates, the procedure was gradually abandoned and replaced with a new surgical technique, shunting. Technical problems such as insufficient illumination, poor lenses, and the fact that scopes were not equipped with cameras were at least partially responsible for the poor outcomes in that time.

These issues were some of the main reasons the procedure was set aside. Decades after this method was initially used, Guiot (1963) and Vries (1978) re-introduced the procedure to neurosurgery by publishing their endoscopic third ventriculostomy (ETV) series with zero mortality and low complication rates (4,6,17). In addition to these encouraging results, technological innovations and advancements in this field, such as more powerful light sources and illumination, and miniature-size video cameras and optic systems, helped to produce thinner and smaller endoscopes. High rates of shunt-related complications and clinical problems in hydrocephalus patients also prompted new searches for ways to better manage hydrocephalus. As a result, ETV re-gained popularity in neurosurgery, with a large number of series showing promising results in the 1990s.

The goal of ETV is to provide free flow of cerebrospinal fluid (CSF) between the ventricular system and the basal cisterns. This is done by fenestrating the floor of the third ventricle between the mamillary bodies and the infundibular recess (Figure 1). When this is done, the CSF in the ventricular system circulates through the prepontine cistern, reaches the cortical subarachnoid space, and is absorbed by the arachnoid villi. Compared the shunt placement, ETV offers a more natural physiological solution to hydrocephalus. It is associated with lower complication rates, avoids implantation of foreign material, and eliminates shunt-related complications such as over-drainage. As a result of these benefits, ETV is now accepted as a mainstay treatment modality for obstructive hydrocephalus.

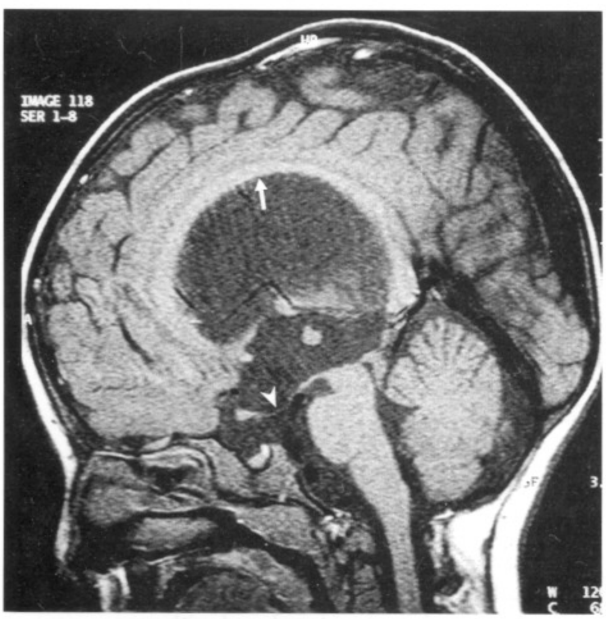

Fig. I: Preoperative MRI scan of a patient shows downward bulging of the third ventricular floor and the appropriate point for fenestration at the floor (arrowhead). Notice the bowing of the thinned corpus callosum (arrow).

ENDOSCOPIC SYSTEMS AND INSTRUMENTATION

Endoscopic surgical systems have undergone revolutionary changes in the last two decades, thanks to technological advancements such as rod lens systems, fiber optic technology, and better illumination with powerful light sources and high resolution. Neuroendoscopic systems can be divided into two main categories: rigid and flexible endoscopes. These have different indications for use, and each has its own advantages and disadvantages. In rigid endoscopes, the view angles vary from 0 to120 degrees. Those with 0-30 degree view angles provide appropriate optical and anatomical orientation for straightforward cases. The outer diameters of rigid endoscopes are usually 3.8-6.2 mm, but may be larger or smaller depending on the endoscope used. The main advantages of rigid endoscopes over flexible endoscopes are better image quality, wider and multiple working channels, stability, and adaptability to stereotactic frames. The disadvantages of these instruments are larger diameter and limited maneuverability. Flexible endoscopes are thinner and less traumatic than rigid endoscopes. Their outer diameter is 2.3-4.6 mm, and their main advantage is superior maneuverability. The main disadvantages of these scopes are narrower working channels and poor image quality.

The neuroendoscopic armamentarium has expanded continuously during the last decade. The most widely used and specially designed neuroendoscopic instruments are probe-perforators, Fogarty catheters, biopsy and grasping forceps, scissors, mono- and bipolar cauteries, suction tips, and laser wires (4,6). Although there are many specially designed neuroendoscopic tools, most straightforward ETV procedures can be performed with a few basic instruments.

INDICATIONS FOR ENDOSCOPIC THIRD VENTRICULOSTOMY

The classic indication for ETV is non-communicating hydrocephalus, in which the patient typically presents with dilated lateral and third ventricles, and a normal fourth ventricle. However, today there is a much wider spectrum of indications for this procedure, including normal-pressure hydrocephalus. Some of the main reasons for this extensive range are increased capability of neuroendoscopic systems due to major improvements in the field; improved expertise of surgeons; increased numbers of reports with favorable long-term results; and increased numbers of shunt-related problems with high social and personal costs. Today, the indications for ETV are somewhat subjective. Some surgeons prefer to use this method even if the success rate of ETV in that specific patient group is only 20-30%. The rationale behind this is offering the patient a chance at shunt-free life. I agree with other authors who have stated that the indications for ETV should be divided into two groups (Table 1) (17). However there is still significant disagreement on this subject. Although there is consensus on good outcome after ETV in patients with late-onset hydrocephalus, there is serious debate about other indications, such as ETV in newborns, or patients with myelomeningocele. Some authors believe that the ETV? success rate is low for patients who have previously had shunts because their subarachnoid spaces are presumed to be obliterated. In contrast, other researchers have reported good success in these cases, and are convinced that this patient group should be managed by shunt removal and ETV (11,17). The patient group with myelomeningocele and hydrocephalus is also controversial. Most authors have reported poor outcome after ETV in these individuals, and have attributed this result to obliterated and abnormal CSF pathways, deformed ventricular anatomy, and a thickened and obstructive massa intermedia. On the other hand, Sayers and Natelson reported relatively high success rate in this patient group, and claimed that these individuals have sufficient CSF flow in the cortical subarachnoid spaces (11).

Table 1: Indications for endoscopic third ventriculostomy.

Strong Indications:
Delayed-onset aqueduct stenosis
Congenital aqueduct stenosis
Obstructive hydrocephalus caused by pineal and posterior fossa tumors
Obstruction of **the foramina** Magendi **and** Luschka
Shunt malfunction in a patient with obstructive hydrocephalus
Shunt malfunction in older patients with spina bifida
Weaker Indications:
Neonates with aqueduct stenosis
Myelomeningocele
Communicating hydrocephalus
Normal-pressure hydrocephalus

The importance of the age at the time of ETV has also been widely discussed. Some researchers have reported poor results in newborn and infants, and have emphasized the negative effect of young age on outcome, whereas others disagree with this explanation (10,13,16). Cinalli et al. reported no difference in results between children younger than 6 months old and an older pediatric age group, and concluded that the age of a child is not a contraindication for ETV procedure(5).

The main contraindications for ETV are history of radiotherapy, significantly distorted ventricular anatomy, abnormally narrow prepontine space due to tumor or vascular lesion, ectatic basilar artery, vascular lesions on the floor of the third ventricle, prematurity, intraventricular hemorrhage, and infection involving the ventricles/meninges.

PREOPERATIVE EVALUATION

Appropriate patient selection criteria and appropriate indications are prerequisites for good surgical outcome with ETV. Careful assessment with preoperative magnetic resonance (MR) imaging is critical in order to avoid complications during surgery and achieve a good outcome. The anatomical details of related structures must be carefully evaluated, including the size of the lateral ventricles, third ventricle, and foramen of Monro; the anatomy and location of the basilar artery and its relationship with the floor of the third ventricle; the width of the prepontine space; and the aqueductal anatomy. Also, a preoperative MR flow study should be obtained as a baseline (20). The surgeon should take all these features into account before deciding to perform ETV and estimating the potential for success with this procedure. Drake described some clinical and radiographic features that favor good outcome with ETV and may be useful for predicting outcome (Table II) (7).

SURGICAL TECHNIQUE

The patient is placed in supine position and the head is elevated to 20-30 degrees with slight flexion of the neck. This is done to prevent postoperative pneumocephalus and reduce the risk of subdural hematoma. An incision is made in the scalp and a burr-hole is drilled on or just in front of the coronal suture on the mid-pupillary line. The optimal entry point for

Table 2: Favorable clinical and radiographical features for ETV (7)

Clinical Features:
Cause of hydrocephalus in high or intermediate success group (see above)
Age>6 months at time of hydrocephalus diagnosis
Age>6 months at time of procedure
No prior radiotherapy
No history of hemorrhage or meningitis
Patients previously shunted
Radiographic Features:
Clear evidence of ventricular non-communication
Obstructive pattern of hydrocephalus
Aqueductal anatomic obstruction
Lack of aqueductal flow void on T2 MRI
Favorable Ventricular Anatomy:
Width of foramen of Monro sufficient to accomodate endoscope
Rigid >7mm
Flexible > 4mm
Thinned floor of third ventricle
Downward bulging floor, draped over clivus
Basilar artery posterior to mamillary bodies
Absence of structural abnormalities
AVM or tumor obscuring floor of third ventricle
Enlarged massa intermedia
Insufficient space between mamillary bodies, basilar artery, and clivus
Basilar artery ectasia

ETV was found as 8 mm anterior to the coronal suture and 28 mm lateral to the midline in a study(12). After a burr-hole of approximately 1 cm diameter is created, the dura is opened in cruciate fashion and a peel-away cannula (12F) or rigid sheath (7 mm), depending on the endoscopic system used, is introduced into the frontal horn of the lateral ventricle. The endoscope is then passed through the cannula into the frontal horn (see accompanying CD). The foramen of Monro is located by following the choroid plexus, anterior septal, and thalamostriate veins, and the endoscope is passed through this opening and placed into the third ventricle. In normal subjects, the mean sagittal diameter of the foramen of Monro is 2.9 mm and the vertical diameter is 5.1 mm (19). This foramen is usually considerably enlarged in hydrocephalic patients, and the endoscope can usually pass through easily without injuring the fornix. Once the endoscope is in the third ventricle, the infundibular recess, tuber cinereum, mamillary bodies, massa intermedia, aqueduct, and posterior commissure can be observed from anterior to posterior. The optic recess, lamina terminalis, and suprapineal recess can be seen if the instrument is a wide angled rigid or flexible endoscope.

Success with ETV is closely related to the surgeon's knowledge of third ventricle anatomy, as the ventricular system can be navigated and worked on through the use of anatomical landmarks. The mamillary bodies are bright white-yellow rounded structures in the floor of the third ventricle, and can be seen just after the scope enters this cavity. If the endoscope is maneuvered anteriorly and superiorly upon entry, the small pink-red infundibular recess (color due to vascularity of the hypothalamic portal system) can be observed. The tuber cinereum is a triangular and often transparent area between the mamillary bodies and the infundibular recess, and it includes the arcuate nucleus of the hypothalamus. In hydrocephalic patients, the tuber cinereum is usually very thin and translucent, and the dorsum sella, clivus, and basilar artery can easily be seen beneath it. Fenestration is performed at the tuber cinereum at the midway between the infundibular recess and the intermamillary point. Ideally, the site of fenestration should be away from the basillary tip. Normally, the mean distance between the infundibular recess and mamillary bodies is 6 mm (range, 3.5-9mm). The mean distance between the basillary artery and the infundibular recess in the normal setting is 10.5±2.3 mm, whereas the corresponding distance in hydrocephalus patients is 12±3.7 mm (9). If the ventricle floor is translucent, the basilar artery may be seen and fenestration is performed distant from it. It is also critical to fenestrate at the above-mentioned mid-point, because more lateral fenestration may cause a third nerve injury.

Fenestration of the floor of the third ventricle may be performed using a blunt probe, Fogarty catheter, the endoscope itself, special scissors, a coagulator, or a number of other instruments, depending on the surgeon's preference. We use an angled blunt probe designed for this purpose (see CD, Cases 1-3), and angle the tip of the probe toward the dorsum sella so as not to injure the basilar artery during fenestration. As mentioned above, the floor of the ventricle is usually quite thin in patients with hydrocephalus, and can be easily punctured with a blunt probe. However, in some cases it may be relatively thick, and the surgeon may prefer to use coagulation or sharp fenestration techniques in these cases (see CD, Cases 2 and 4). However, I do not recommend using coagulation to fenestrate the floor, as this may damage vascular structures below and may cause thermal injury to the hypothalamus.

After the floor of the third ventricle is punctured, the fenestrated site is enlarged using a 3F Fogarty catheter. The catheter is passed through the puncture hole, its balloon is inflated, and the catheter is then withdrawn to enlarge the hole. Using this method, a fenestration of 5-6 mm diameter is created. It is important to remember that the Fogarty catheter may injure vascular structures and the third cranial nerve below, and should not be advanced into the prepontine space too much. The proximal end of the balloon. should be visible to the surgeon. Once this enlarged passageway is formed, the endoscope is inserted into the prepontine space to explore the basilar artery and its tributaries, the pons, the dorsum, and the clivus. It is not uncommon to observe a second membrane, often connected to the Lilliquest membrane, in the prepontine space. The main purpose of this exploration is to ensure there is no other membrane obstructing free CSF flow in the prepontine space. If there is such an obstructing membrane, it must also be fenestrated with a blunt probe and enlarged with a Fogarty catheter, as described above (see CD, Case 9). After the prepontine space has been explored, the endoscope is withdrawn into the third ventricle and the examiner will observe pulsations of the floor along with "flapping" of the edges of the newly created opening as CSF flows through indicating a patent ventriculostomy (see CD).

It is not unusual to observe some bleeding during fenestration, especially if the floor is thick and vascular. However, this is easily stopped by irrigating the field with Ringer's lactate for a while. Another way to stop hemorrhage from the edges of the new opening is to inflate the Fogarty balloon just at the level of the opening so that it compresses the edges. The inflated balloon should be kept in place for 15-30 seconds. When the procedure is complete, the endoscope is withdrawn slowly, exploring the third and lateral ventricles to ensure there is no active bleeding. A piece of Gelfoam® is placed in the burr-hole and the scalp is closed in standard fashion. Some surgeons leave a ventricular drain in place after ETV. The purpose of this is to measure intracranial pressure (ICP) and be able to drain CSF if necessary. At our center, we do not place a ventricular drain if there are no peroperative problems.

Another endoscopic procedure that can be performed alone or in addition to ETV is aqueductoplasty (see CD, Cases 10 and 11). If aqueductoplasty is planned, the burr-hole should be placed 2-3 cm in front of the coronal suture. The endoscope is inserted into the third ventricle as described above, but is directed posteriorly, in contrast to what is done in ETV. The massa intermedia is often thin in hydrocephalic patients due to increased distance between the thalami. The endoscope is advanced above or below the massa intermedia, depending on the patient's anatomy. The posterior commissure, pineal recess, and aqueduct are explored. If there is aqueductal stenosis, the aqueduct appears like a "fish mouth." If there is an aqueductal web or bands, these membranes can be perforated with scissors or a Fogarty catheter. In case of aqueductal stenosis, a Fogarty catheter is introduced into the aqueduct without any force. The balloon is inflated slightly and kept inflated for 10-15 seconds. Thereafter, the balloon is deflated, the catheter is advanced further, and the balloon is re-inflated and held in position again for 10-15 seconds. These steps are repeated until the Fogarty can be advanced into the fourth ventricle with no resistance. It is very important not to force the catheter if there is significant resistance in the aqueduct. If this is the case, the procedure should be abandoned rather than injure the periaqueductal structures with the catheter. If the patient has long-segment stenosis and the surgeon is concerned about the long-term patency of this passage, an aqueductal stent may also be considered.

POTENTIAL PROBLEMS

Although ETV is a straightforward procedure, there are a number of potential problems. Most of these relate to variations in third ventricle anatomy (15,19). Thick and opaque third ventricular floor is one of the most frequently encountered variations, with an approximate frequency of 16% (18) (see CD, Cases 2 and 4). Another significant detail in preoperative MRI assessment is the the distance between the pons and clivus in prepontine space. If this distance is smaller than 4 mm, a fully inflated 3F Fogarty catheter balloon may compress the basilar artery and pons . In these cases the procedure the fogarty should be inflated less than usual (see CD, Case 5).

Other anatomic variations relate to the nature of the ventricle floor. The floor of the third ventricle may be steep because the upper level of the dorsum and infundibular recess are elevated compared to the mamillary bodies. Puncturing a steep ventricle floor can be very difficult (see CD, Case 6). It can also be challenging to puncture a floor that is unusually resistant. If the floor is stretched excessively during puncturing attempts, postoperative diabetes insipidus and fever related to hypothalamic injury may develop. In addition, it may not be possible to visualize the basilar artery and dorsum if the floor is thick and opaque, and this increases the risk of vascular injury during puncturing. Basilar artery injury is most serious potential complication of ETV, and this can be lethal. The location of the basilar artery should be clearly established both pre- and peroperatively, fenestration should be performed anterior to this vessel, and cautery should not be used to perforate the floor.

Hypervascular ventricular floor is another potential problem in ETV, and may cause significant bleeding during fenestration (see CD, Case 7). Although it is not common, spontaneous fenestration of the floor of the third ventricle may also be seen. These fenestrations are usually small and partial; thus, standard fenestration with a 3F Fogarty catheter should be created even if the surgeon notes spontaneous fenestrations in the floor during the procedure (see CD, Case 8).

Another potential problem during ETV is upward bulging of the ventricle floor. The floor can herniate upward and obliterate the third ventricle, making it very challenging to find the fenestration hole again and continue the procedure (1). Dilation of the infundibular recess may also cause problems during surgery. The anterior third ventricle may herniate into the sella in these cases, and fenestration may unintentionally create an opening into the sella.

As stressed above, careful preoperative MRI assessment is important to avoid unwanted problems. Knowing the basilar artery anatomy and location are also very significant factors for planning and performing successful ETV. Missing an ectatic or anteriorly placed basilar artery during preoperative MRI evaluation can lead to catastrophe. It should be noted that the basilar artery may be found more anterior to the mamillary bodies than normal in up to 12.9% of patients, especially in older individuals (Figure 2) (9).

Finally, in some cases, the ventricle anatomy may be completely disrupted with almost all anatomical landmarks absent (8). These cases are especially challenging, and the surgeon's experience is most important determinant of successful outcome (see CD, Case 9).

POSTOPERATIVE EVALUATION

Ventricle size often does not change after ETV. Reports state that only 16-33% of patients have smaller ventricles after this procedure (3,14). Although

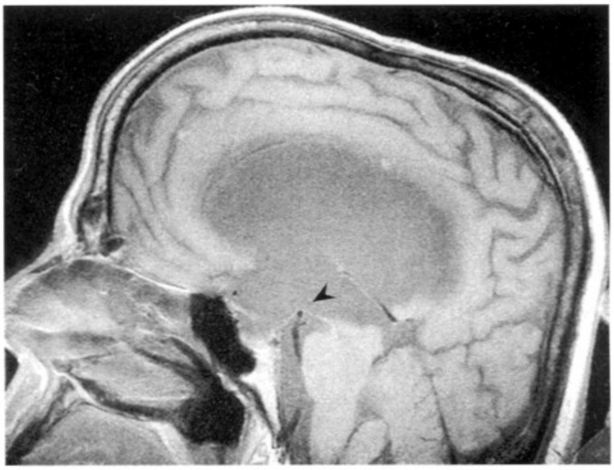

Fig. II: MRI scan of an older hydrocephalic patient shows anteriorly and upwardly displaced basilar artery (arrowhead). Notice the tenting effect of basilary tip on the third ventricular floor.

observations of flapping of the edges of the fenestration site during the procedure implies patency of the ventriculostomy and free CSF flow, this sign alone not very reliable. Findings indicating clinical improvement are considered more valuable for assessing the success or failure of ETV. Clinical findings such as resolution of papilledema, normalization of ICP, relaxation of the fontanelles, and stable head circumference indicate a successful procedure.

Several objective tests can also be used to evaluate success. Per- or postoperative flow studies performed with radiopaque or radioisotope materials may also be useful for assessing patency after ETV. Another option is to leave an external ventricular drain in place and monitor normalization of ICP postoperatively. However, it is important to remember that ICP may remain high for the first few days post-surgery (adaptation period), and this does not indicate failure. Today, MR flow studies are the most widely used and reliable postoperative tests for assessing success of ETV. These studies provide detailed information on the subject's CSF flow dynamics. Sagittal T2-weighted turbo inversion-recovery MR images may provide information regarding the absence or presence of flow void in the aqueduct. However, if the aqueduct is smaller than 1 mm diameter, there may be no signal void even though there is some flow. Flow-sensitive cardiac-gated cine phase-phase contrast MR images are used for quantitative and qualitative CSF flow studies, and this is one of the most frequently used methods for assessing patency in these cases (Figure 3 and 4) (8,9,20).

COMPLICATIONS

As noted above, the most serious complication of ETV is basilar artery injury. Although very rare, this can lead to pseudoaneurysm or even death. Injuries that occur during floor puncture are more common. These include damage to the hypothalamus, pons, cerebral peduncle, and third cranial nerve. The most frequent surgical complication in ETV is bleeding, and this usually occurs due to injury of the ependymal vessels or choroid plexus. To avoid these complications, it is very important to remember that significant neurovascular structures may be very close to the endoscope during the procedure, even if they are not directly in view. Table III shows approximate rates of various complications of ETV based on published series (17).

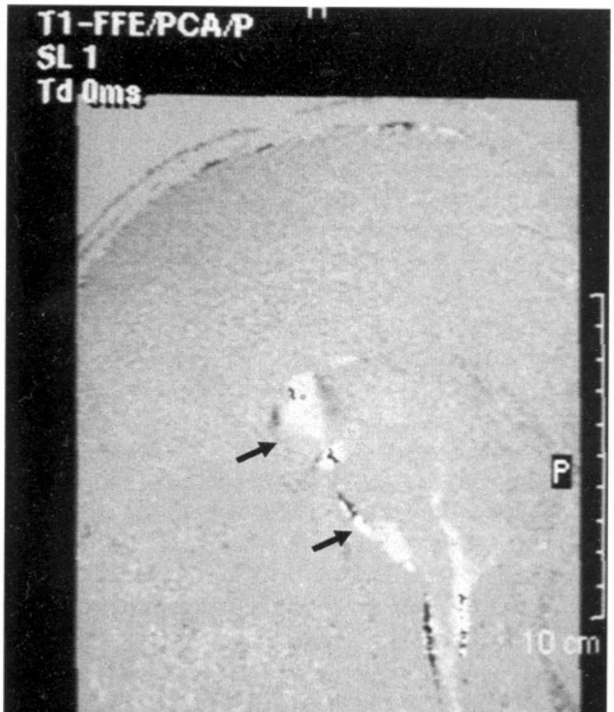

Fig. III: Early postoperative Cine PC MR image of a patient shows continuous caudal flow through ventriculostomi site between the third ventricle and prepontine space which implies a patent fenestration (arrows). Notice the presence of caudal flow in cervical subarachnoid space as well and absence of any flow void in the aqueduct of Sylvii.

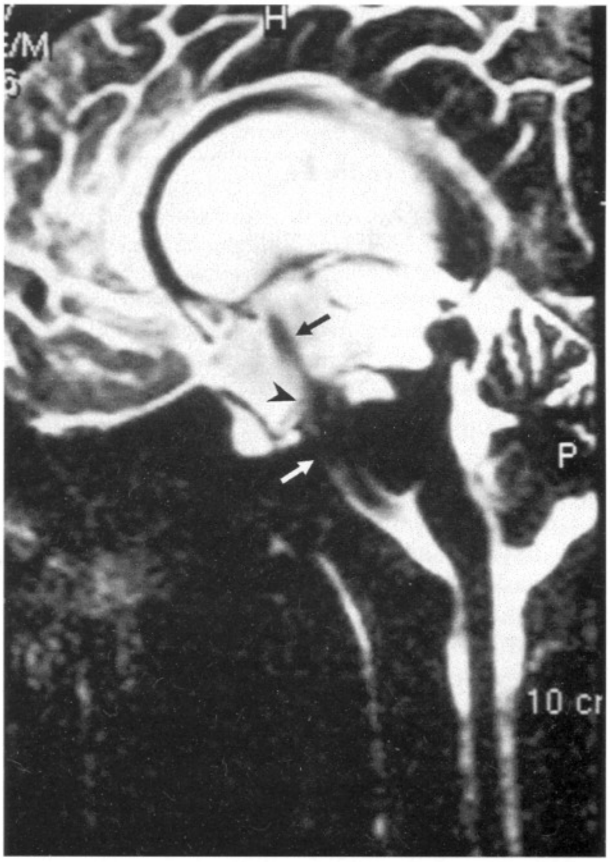

Fig. IV: Postoperative MRI scan of a patient shows the fenestration site (arrow head) and flow void in third ventricle and prepontine space (arrows).

OUTCOME OF ENDOSCOPIC THIRD VENTRICULOSTOMY

Successful ETV is defined as improvement of clinical findings after the procedure with no need for shunt placement. Rates of success with this procedure vary considerably, depending on patient age and the type and etiology of hydrocephalus. Overall success rates with ETV in different groups has been given in Table IV (17). A meta-analysis done by Pople et al. in 2001 documented the highest ETV success rates in patients with hydrocephalus related to aqueductal stenosis, spina bifida, and mass lesions in the tectum, pineal region, and posterior fossa (17). The lowest rate was in patients with a history of central nervous system infection. These investigators calculated an overall success rate of 65-75% with ETV.

One of the most controversial subjects related to ETV outcome is the success rate in infants. Cinalli et al. reported that the long-term success rate with ETV in infants younger than 6 months was 72%,

Table 3: Complication rates in endoscopical third ventriculostomy (17).

Neurological deficit		2.2%
Hemiparesis/plegia	0.4%	
Herniation **syndrome**	0.1%	
Fornix injury	0.4%	
Brainstem injury/cranial nerve deficit	1.3%	
Hypothalamic impairment	1.2%	
Asymptomatic Intrapar. Hematoma	0.5%	
Intracranial infection		3%
CSF **leakage**		2%
Extraparenchymal hemorrhage		**2.3%**
Intraventricular hemorrhage	1.8%	
Subdural hematoma	0.3%	
Epidural hematoma	0.1%	
Basilar **artery** injury	0.1%	
Mortality		0.1%
Overall complication rate		9.4%
Complication range in series		4.4-34.4

which is similar to the rate in adults (5). In contrast, Javadpour et al. documented a success rate of 21% in infants (10). The rate reported by Buxton et al., who investigated ETV in 19 premature babies of mean age 8.9 weeks, was 32% (2). These discrepancies show how variable success rates with ETV can be. Classifying success in relation to etiology may be helpful for selecting surgical candidates. Drake and Iantosca devised the following system based on this rationale (7):

Table 4: Success rate of endoscopic third ventriculostomy in different patient groups (17)

Cause	
Pineal/Tectal tumors	84%
Nontumoral aquaductal stenosis	77%
Other obstructive mass lesions	71%
Myelomeningocelel	70%
Intraventricular hemorrhage (adults)	62%
Normal-pressure hydrocephalus	57%
Slit ventricle syndrome	50%
Posthemorrhagic hydrocephalus (neonates)	8%
Age	
Age>2 years	78%
Age<2 years	54%
Age<1 years	26%
Previous shunt surgery	
Previously shunted	68%
Never shunted	65%

High Success Rate (>75%)
Acquired aqueductal stenosis
Tumoral mass
Medium Success Rate (50-70%)
Myelomeningocele
    Shunted adult
Congenital **aqueductal** stenosis
Cystic lesions
    Arachnoidal cysts
    Dandy-Walker **syndrome**
Shunted patients
    Slit ventricle syndrome
    Shunt infection
    Shunt malfunction
Low success rate (<%50)
Myelomeningocele
    Never shunted, **newborn**
Post-hemorrhagic hydrocephalus
Post-infectious hydrocephalus

If a patient continues to exhibit persistent headache, increased ICP, and bulging fontanelles without clinical improvement, or if CSF leakage from the burr-hole is observed after ETV, it is highly possible that the procedure has failed. In addition to technical problems, failure may be due to inappropriate indication for ETV. The most common reasons for failure in the early postoperative period are presence of a second membrane in the prepontine space, obliterated subarachnoid spaces, and insufficient circulation or absorption of CSF. The most frequent cause of late failure is sealing of the fenestrated floor due to fibrosis, and the procedure should be repeated in these cases (5).

Another noteworthy issue is the need for extensive follow-up of these patients. One study showed that the patency rate in patients who have undergone ETV decreases over time to 44% at 10 years post-surgery (17). Thus, long-term radiologic follow-up should be done in these cases, and the procedure should be repeated if necessary.

CONCLUSION

Today, ETV has been widely used, with high success rates and an extensive range of indications. This procedure has significant advantages over shunting when it is used in appropriate cases. Success with ETV is strongly dependent on surgical experience and meticulous preoperative evaluation. Detailed knowledge of third ventricle anatomy, ability to navigate the ventricle using surgical landmarks, and experience with endoscopic surgical technique are prerequisites for success with this procedure.

Note:

The CD that accompanies this article shows some ETV procedures that we performed at Hacettepe University Hospitals. The references made to the CD in the text identify actual images of the surgical techniques and anatomical details that are mentioned.

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