Endoscopic Third Ventriculostomy: Our Experience of Consecutive 50 Cases at a Tertiary Care Center

Ramesh Chandra Venkata Vemula1  BCM Prasad1  Kunal Kumar1

1Department of Neurosurgery, Sri Venkateswara Institute of Medical Sciences (SVIMS), Tirupati, Andhra Pradesh, India

Address for correspondence Kunal Kumar, MBBS, MS, MCh, Department of Neurosurgery, Sri Venkateswara Institute of Medical Sciences (SVIMS), Tirupati 517507, Andhra Pradesh, India (e-mail: kunwar85ms@gmail.com, ikunwar_kk@yahoo.com).

Abstract

Objective The aim of this study was to do a retrospective analysis of the various neurosurgical pathologies where endoscopic third ventriculostomy (ETV) was used and to evaluate the outcome and prognosis.

Methods The retrospective data collection was done for the patients who underwent ETV with or without other adjunct procedures; the results were prepared for clinical presentation, diagnosis, surgical approach, and surgical goal; and success rate and prognosis were analyzed and compared with other studies.

Results A total of 50 patients were included in the study, with overall success rate of ETV as 88%; aqueductal stenosis was the most common indication where ETV was used; headache and vomiting were the most common presenting complaints followed by ataxia and visual blurring; and ETV provided flexibility in its use with biopsy, abscess drainage, temporary external ventricular drain placement, etc.

Conclusion ETV being superior to ventriculo-peritoneal shunt for obstructive hydrocephalus provides flexibility in its use and possibly is a useful adjunct to prevent postoperative hydrocephalus after endoscopic intraventricular surgery; proper case selection in accordance to ETV success score yields a better success rate. In experienced hands with proper precautions, perioperative complications can be kept at minimum. Wherever possible, in cases of obstructive hydrocephalus, especially in patients >1 year of age, ETV should be the treatment of choice. We recommend a proper case selection, including preoperative detailed reading of sagittal magnetic resonance imaging scan, to improve the success rate with less complication.

Keywords

► ETV
► CSF
► hydrocephalus
► success rate
► ETVSS
► trajectory

Introduction

The first neuroendoscopic procedure was introduced in 1910, when L'Espinasse performed a cauterization of choroid plexus with a cystoscope. The other pioneer in neuroendoscopy was Walter Dandy. He published his results in 1913. The first endoscopic third ventriculostomy (ETV) was performed by William Mixter in 1923. This successful technique later served as a model for modern neuroendoscopy.1 Initial reports were associated with higher morbidity and mortality due to the primitive nature of instruments and less experience.2 Added with technical advancements in optics and energy sources as well as experience and widespread use, now ETV has replaced shunt as the procedure of choice for obstructive hydrocephalus.1,3 It allows the cerebrospinal fluid (CSF) to be internally diverted to the basal cisterns and eventually be reabsorbed by arachnoid granulations. It has lower
infection rates, no foreign material, and no over-drainage. The success rate of ETV is variable among series, with reported rates between 50 and 94%. It is indicated in all cases with an obstruction between the third ventricle and the subarachnoid space with preserved CSF absorption from subarachnoid space, for example, aqueduct stenosis, far distal obstruction (intraventricular membranous obstruction, extraventricular compression, in case of Dandy-Walker syndrome, and Chiari malformation), tumors and cystic lesions (tumor localization in the brainstem, posterior fossa, thalamus, pineal region, third and fourth ventricle, and other localization, for example, cerebellopontine angle, frontal lobe, or diffuse growth pattern), cerebellar infarction, hemorrhage-related obstructive hydrocephalus, infection-related hydrocephalus, and congenital malformation-related hydrocephalus. In present day, mortality has been reported to be 0.5 to 1.0% and complication around 9%.

### Objectives

The objective of this study was to retrospectively analyze various neurosurgical pathologies and their presentation, indication, perioperative findings, outcomes, complications, and prognosis where ETV was used in our institute from 2014 to 2019, and calculating the overall success rate of ETV and comparing the results with other studies.

### Materials and Methods

The study was conducted in the Department of Neurosurgery, Sri Venkateswara Institute of Medical Sciences, Tirupati, in the Indian state of Andhra Pradesh, from 2014 to 2019.

Retrospective data were collected for all patients who underwent ETV for various indications from Operation Theatre database followed by collection of further details from Medical Record Section and Radiology database. A total number of first 50 consecutive cases were included in the study. A total of 312 patients underwent surgery for hydrocephalus within the study period (2014–2019), out of which 50 patients underwent ETV. The criteria for selecting patients were subjective, primarily based on the presence of obstructive hydrocephalus in majority of cases, whereas in some cases ETV was performed as an adjunct to ventricular endoscopic procedure.

Surgery was performed by senior neurosurgeon(s) keeping with standard neurosurgical protocol. Patient was kept in supine position with neck slightly flexed, fixed in threepin Mayfield fixator in case of adults and horseshoe support for pediatric cases; all cases were operated under general anesthesia. Preoperative planning was done with trajectory of ETV defined on sagittal scan (magnetic resonance imaging/computed tomography [MRI/CT]), preferably at or anterior to Kocher’s point 2.5 to 3 cm lateral to midline along the mid-pupillary line. On the right side (i.e., nondominant side, if not specifically indicated), with proper aseptic measures, 2 to 3 cm vertical incision was made bone deep; burr hole was made with Codman burr, dura was coagulated then opened in cruciate manner and its margins coagulated. STRYKER endoscope system with rigid (0 and 30 degrees) endoscope and Karl Storz camera were used after adequate illumination and white balance. Using free-hand method, 10 mm obturator sheath with blunt end trocar was used. Lateral ventricle was preferably hit at 5 to 6 cm depth; then trocar was removed and endoscope inserted. After visualization of lateral ventricle and identifying defined landmarks, third ventricle was reached via foramen of Monro. Mammillary bodies, infundibular recess, and optic chiasma were identified followed by puncture of intermammillary membrane with Fogarty balloon catheter. Fogarty balloon was inflated with up to 2 to 4 cc saline to enlarge the stoma (or controlled bipolar cautery was used with low current in selected cases of thick floor of third ventricle). Endoscope was further negotiated via the stoma to inspect interpuduncular cistern and open the Liliequist membrane. After that as per the need on individual basis other procedures were done together with ETV. Ringer lactate was used for intraoperative saline wash. After ascertaining hemostasis, obturator sheath and endoscope were removed synchronously under vision. Cortical opening was packed with geloam. Dural closure was done with artificial, duragen graft. Burr hole was filled with bone dust or bone cement and skin closure was done in two layers, followed by aseptic dressing. In all cases, a single burr hole was used with properly planned trajectory.

Postoperative scan was done for all patients within 6 hours of operation and all patients were followed for 6 months before deciding success.

For overall and group-wise performance, Kulkarni et al’s score was used, whereas clinical improvement in symptomatology on individual basis was used to define improvement and success of the procedure. If the patients did not improve clinically and ultimately required re-diversion procedure, it was considered as failure of the procedure, within a follow-up period of 6 months.

Success of ETV was measured based on age and pathology, and overall success was compared to other studies.

### Results

Out of total 50 patients, 35 were male and 15 were female; 38 patients were aged >10 years, 10 patients between 1 and 10 years, and 2 patients between 6 months and 1 year (Table 1).

Overall, headache was the most common symptom, followed by vomiting and gait disturbance. Visual blurring was relatively more common in adults, whereas altered sensorium and seizure were common in children (Table 2).

For tumors/space occupying lesions, ETV was additionally performed either for diagnostic biopsy (thalamic/brainstem/pineal region tumor), therapeutic intent (thalamic abscess/neuromeningeal cyst/arachnoid cyst/colloid cyst/intraventricular tumor), or for palliative intent (vestibular schwannoma/medulloblastomas). Most common indication for ETV in our series was aqueduct stenosis (Fig. 1).

Depending upon the pathology, flexibility in use of ETV was shown, with only ETV in 24 cases, ETV with biopsy in 8 cases, and ETV with tumor excision/coagulation in 6 cases,
while in 5 cases an additional aqueductoplasty was done, in 3 cases septostomy was also done, in 1 case aspiration of pus from thalamic abscess was done, and in 1 case fenestration of neurenteric cyst wall with excision of daughter cyst was done. In three cases, Ommaya reservoir and in another three cases external ventricular drain (EVD) catheter were inserted after the procedure (►Fig. 2).

Only one case had significant intraoperative bleeding, which was not controlled with saline irrigation and finally dry-field maneuver was used to control bleeding. Six patients had minor intraoperative bleeding, which was controlled with saline irrigation. Three patients had postoperative CSF leak among which one patient had wound dehiscence, all three underwent suturing of wound under local anesthesia. Two patients developed meningitis, three patients had vomiting, and two had seizures; one had intraparenchymal bleed and one patient had venous infarct, both along the line of insertion of endoscope obturator, but none of them were clinically significant and were managed conservatively (►Table 3).

Six cases required revision procedure amounting to an overall success rate of ETV in our series of 88%; in none of the patients redo ETV was done; in all patients ventriculo-peritoneal (VP) shunt was done.

There was fortunately no mortality, with intraoperative complication rate of 14%, which was managed successfully without any event, clinical complication rate of 16%, none of them serious and managed well during the hospital stay, and radiological complication rate of 4% (excluding failed ETV cases).

As per the ETV success score (ETVSS), the cumulative preoperative success score was 78.4%, which although was less than the actual success rate of 88%, but correlated quite well on an individual basis (►Table 4).

Perioperative positioning, incision marking, and intraoperative endoscopic pictures have been shown in ►Figs. 3 and 4 respectively. Pre- and postoperative radiological imagings of

**Table 1** Age distribution of cases in our study, according to Kulkarni et al’s endoscopic third ventriculostomy success score age grouping

<table>
<thead>
<tr>
<th>Age</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1 month</td>
<td>0</td>
</tr>
<tr>
<td>1–6 months</td>
<td>0</td>
</tr>
<tr>
<td>6 months to 1 year</td>
<td>2</td>
</tr>
<tr>
<td>1–10 years</td>
<td>10</td>
</tr>
<tr>
<td>10–20 years</td>
<td>9</td>
</tr>
<tr>
<td>20–40 years</td>
<td>15</td>
</tr>
<tr>
<td>40–60 years</td>
<td>10</td>
</tr>
<tr>
<td>&gt;60 years</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table 2** Presenting signs and symptoms according to frequency

<table>
<thead>
<tr>
<th>Presenting complaints</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Headache</td>
<td>39</td>
</tr>
<tr>
<td>Vomiting</td>
<td>26</td>
</tr>
<tr>
<td>Gait disturbance</td>
<td>13</td>
</tr>
<tr>
<td>Visual blurring</td>
<td>11</td>
</tr>
<tr>
<td>Altered sensorium</td>
<td>9</td>
</tr>
<tr>
<td>Giddiness</td>
<td>6</td>
</tr>
<tr>
<td>Urinary incontinence</td>
<td>6</td>
</tr>
<tr>
<td>Limb weakness</td>
<td>5</td>
</tr>
<tr>
<td>Memory deficit</td>
<td>4</td>
</tr>
<tr>
<td>Seizures</td>
<td>4</td>
</tr>
<tr>
<td>Ophthalmoplegia</td>
<td>4</td>
</tr>
<tr>
<td>Facial nerve palsy</td>
<td>3</td>
</tr>
<tr>
<td>Fever</td>
<td>3</td>
</tr>
</tbody>
</table>

**Fig. 1** Primary indications for doing endoscopic third ventriculostomy.
six patients with different pathologies have been shown in ►Figs. 5 and 6.

**Discussion**

**Clinical Features**

The presenting complaints and clinical features of the patients in the various studies were similar, with headache being most common followed by vomiting, gait disturbance, visual symptoms, altered sensorium, limb weakness, seizures, etc., in slightly varying frequency depending upon the predominant primary pathology and age characteristics (►Table 2).1-3,5,6

**Overall Success Rate**1-3,5-10

Overall success rate of ETV reported in literature in different studies varied from 60 to 90%; in our series it was 88%. When compared to other studies, success rate ranged from 75 to 89% (►Fig. 7), which certainly depended upon three major factors: age, neurosurgical pathology, and surgeon’s experience. The first two factors signify the importance of proper case selection and defining the operative goal and preoperative planning to execute it, so as to avoid any unforeseen perioperative complication and failure. Success rate obviously improves with surgeon’s experience, but in the long-term follow-up success rate falls below the immediate success rate, due to reports of delayed failure of ETV most commonly due to stenosis of third ventricular stoma in long term in some patients.

Moreover, definition of success in ETV has not been defined evenly; the radiological regression of hydrocephalus takes long time (some studies consider 3–6 weeks’ time to look for radiological improvement), may be incomplete, and sometimes may not be there; the clinical parameter is more important. We also consider clinical parameter more indicative than radiological parameter to define success, but an objective definition is still missing. A subjective improvement of more than 50% improvement in the first week postoperatively may be considered adequate.

**Age and ETV**

Age distribution varied among studies, with some studies primarily focused on infant and pediatric population, some on adult population4-16 and elderly population, and some studies included all age groups, like us.2,5-10
The success rate of ETV in other studies for pediatric population was 20 to 70%, whereas it was 75% in patients >65 years, and overall success rate ranging from 50 to 100% which varied depending upon the age distribution and neurosurgical pathologies in that study. The success rate of ETV in our series was found to correlate well with other studies and in harmony with ETVSS, with success rate increasing as per age, with best results in the age group 40 to 60 years (100%). But post 60 years the success rate was 75%, maybe due to a limited number of cases post 60 years in our group and reflecting effect of age-related degenerative changes, though it was similar to the study by Niknejad et al. with a success rate in their study also being 75% in patients >65 years of age.

Two patients were infant with ETV success rate of 50%, but with the available data and present literature we consider opting other modes of CSF diversion rather than ETV due to low success rate, maybe due to overproduction of CSF rather than obstruction being a prominent factor in causation of hydrocephalus in infants and lack of expected CSF pressure gradient generated post-ETV between the third ventricle and prepontine cistern due to open fontanelles.

**Neurosurgical Pathology and ETV**

Undoubtedly, aqueduct stenosis, tectal brain tumors, and noninfectious causes have fared best in short- and long-term reports of ETV success, similar to our and other studies. Intraventricular infection and hemorrhage hamper the success of ETV, and since the scope of ETV has enlarged with addition of other procedures, in miscellaneous situations, the success depends more on better case selection and definition of success preoperatively. Doing ETV in nontectal brain tumors is better than that in VP shunt, provided that definitive treatment (surgery/radiotherapy) of those cases should not be delayed, and taking biopsy in cases of thalamic and pineal region tumor and CSF samples in pineal region and vestibular schwannoma provides additional information in planning further management with least morbidity.

**Complications in ETV**

Complications in ETV have been better classified as vascular, neural, endocrine, infectious, and anesthesia related. Vascular complications basically consist of intraoperative bleed (minor or major) and intra-/extra-axial hematoma; the former is more common with a reported rate of 16.5% and 0.5% by Jung et al., which was similar to our study of 12% and 2%, respectively. Minor bleed was controlled with continuous saline irrigation and major bleed, which occurred while taking thalamic tumor biopsy, was controlled with a dry-field maneuver, without any major issues postoperatively, with postoperative EVD in two of these cases. One patient had small hematoma and one patient had a small venous infarct along the trajectory of port insertion, which was minor and managed conservatively.

Neural injury in the form of cerebral herniation syndrome due to excessive irrigation, fornical injury, thalamic injury, Table 4  ETVSS as proposed by Kulkarni et al

<table>
<thead>
<tr>
<th>Score</th>
<th>Age</th>
<th>Etiology</th>
<th>Previous shunt</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>&lt;1 month</td>
<td>Postinfectious</td>
<td>Yes</td>
</tr>
<tr>
<td>10</td>
<td>1 month to &lt;6 months</td>
<td>Myelomeningocele, colloid cyst, nontectal brain tumor</td>
<td>No</td>
</tr>
<tr>
<td>20</td>
<td>6 months to &lt;1 yr</td>
<td>Aqueductal stenosis, tectal tumor, other</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>1 to &lt;10 yr</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>&gt;10 yr</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviation: ETVSS, endoscopic third ventriculostomy success score.
Note: The ETVSS is calculated as age score + etiology score + previous shunt score.

![Fig. 3](image_url) Positioning and marking of skin incision at right Kocher’s point.
Endoscopic Third Ventriculostomy

Vemula et al.

and periaqueductal injury with resultant cognitive and neurological deficits, seizures, and gaze paresis has been mentioned with an overall complication rate of 0.5 to 1.4% as compared to 4% in our series due to new transient onset seizures in two patients, which was managed with antiepileptics. No permanent neurological deficit was noted in any of our patients.

Endocrine disturbances (0.94%) in the form of diabetes insipidus, electrolyte imbalance weight gain, and precocious puberty have been noted due to injury to tuber cinereum or infundibulum in the process of making stoma in floor of third ventricle too close to infundibular recess, but practically none of the above complications were noted in any of our patients.

Reports of CSF leak from the incision site have been noted, ranging from 1.7 to 5.2%, which was 6% (three patients) in our case series, one of which was associated with wound dehiscence and low-grade meningitis in the same patient; all three were patients managed with resutting of wound under local anesthesia under aseptic conditions.

Meningitis and/or ventriculitis has been reported as 1.8 to 6.1%, which was 4% (two patients) in our series; both patients had mild-moderate meningitis, were managed with empirical broad-spectrum antibiotics as per institute protocols, and recovered well.

Mortality rates of 0.1 to 1.0% have been reported, while in our series no mortality was seen.

For prevention of complications in ETV, several precautions are taken like proper patient selection, avoiding over-enthusiasm about endoscopy, preoperative work-up and preanesthetic check-up with normal coagulation profile, defining the goal of surgery, good operating camera and endoscope system, rigid head immobilization, marking working trajectory on mid-sagittal scan (MRI better than CT), measuring the thickness of floor of third ventricle and distance of basilar artery from floor of third ventricle, relative position of basilar artery from the selected trajectory, coagulation of dura before dural opening, using neuronavigation and endoscope fixation system if available, opting to enter the ventricles from nondominant hemisphere, proper inspection and identification of intraventricular endoscopic landmarks, gentle negotiation via foramen of Monro, making stoma in the floor of third ventricle after preidentification of infundibular recess, basilar artery, using blunt instruments as much as possible, gentle and slow inflation of Fogarty balloon catheter, gentle negotiation of endoscope via floor of third ventricle and puncture of Lilliequist membrane, checking for free flow of CSF via the stoma along the pressure gradient, moderate saline irrigation with ringer lactate with equal outflow of

Fig. 4 Intraoperative pictures during endoscopic third ventriculostomy (ETV) procedure: (A) view of right foramen of Monro with visualization of septal vein, thalamostriate vein, and choroid plexus; (B) view of floor of third ventricle with visible mammillary bodies bilaterally, inter-mammillary membrane, and infundibular recess and optic chiasma anteriorly; (C) floor of third ventricle being punctured with Fogarty balloon catheter; (D) inflated Fogarty balloon catheter; (E) visible third ventriculostomy with visible basilar artery through the stoma; (F) ETV done in a case of choroid plexus papilloma with cauterization of choroid plexus and biopsy; (G) ETV done in a case of thalamic neurenteric cyst with visible daughter cyst; (H) ETV done in a case of thalamic abscess with visible abscess cavity before aspiration; (I) ETV done in a case of pineal region tumor for biopsy with visible tumor.
saline, avoiding any forceful maneuver that can lead to neural injury, controlling any bleeding, taking adequate biopsy (if indicated), cautious use of cautery if required, withdrawing endoscope and obturator under vision, sealing the cortical wound with a piece of surgical-gelfoam, using an artificial dural graft for dural closure, filling the burr hole with bone dust/bone cement, skin closure in two separate layers with proper antiseptic dressing, etc.

In our series, we tried our best to comply with the above suggestions, except that we used the free-hand method with blind port insertion due to lack of neuronavigation and endoscope fixation device.

**Risk Factors for Failure of ETV**

Fukuhara et al.\(^9\) have indicated three major factors for failure of ETV: age less than 6 months, intraventricular infection (preoperative or perioperative), and cases like Dandy-Walker or Arnold-Chiari malformation. Additional causes of failure have been mentioned as posthemorrhagic hydrocephalus, intraoperative major bleeding, communicating hydrocephalus, and very thick and nontransparent floor of the third ventricle.\(^20\)

As reported by Moorthy and Rajshekhar,\(^21\) failure rates were higher in posthemorrhagic, postinfectious, communicating hydrocephalus; in infants, thick floor of the third ventricle, scarred basal cisterns, patent aqueduct, and routine use of EVD.

Of the six patients who required redversion of CSF in the form of VP shunt in our series, one patient (postinfectious aqueduct stenosis) did not show improvement, either radiological or clinical, in the postoperative period and was converted to VP shunt within 48 hours. Two cases (one medulloblastoma and one postinfectious aqueductal stenosis with adhesions) after initial improvement deteriorated on postoperative days 5 and 7 respectively and underwent VP shunt. One patient presented with decreased sensorium after 14 days of surgery (congenital aqueduct stenosis), while remaining two patients (one pineal region germ cell tumor under radiotherapy treatment and one postoperative intraventricular epidermoid) on postoperative days 31 and 46. None of the patients had a previous history of shunting or any CSF diversion procedure. Of the common finding in failed cases of aqueduct stenosis was a thick floor of the third ventricle.

ETV has also been indicated and done in cases like normal pressure hydrocephalus (NPH), communicating hydrocephalus, congenital malformation-related hydrocephalus (Dandy-Walker and Arnold-Chiari malformation), obstruction due to giant aneurysm, and shunt malfunction, but experience in these indications is nil. In some studies, the efficacy of ETV in NPH, communicating hydrocephalus, and...
shunt malfunction has been reported to be approximately 70%, but further evaluation needs to be done.\textsuperscript{22-24}

**ETV vs VP Shunt**

ETV has been proven beyond doubt to be the treatment of choice for obstructive hydrocephalus, with more flexibility in use, easy learning curve, lesser complication rate, additional advantage of obtaining biopsy tissue in certain cases, avoidance of any foreign material, leaving the peritoneal cavity virgin, avoiding abdominal complications associated with VP shunt, avoiding complications related to sudden decompression of ventricles like extradural hematoma/subdural hematoma/coning, and being more physiological. It is also cost-effective, takes lesser operation time, lesser hospital stay, and has less morbidity and mortality in experienced hands.

**Conclusions**

ETV being superior to VP shunt for obstructive hydrocephalus provides flexibility in its use and possibly is a useful adjunct to prevent postoperative hydrocephalus after endoscopic third ventriculostomy.
intraventricular surgery; proper case selection in accordance to ETVSS yields a better success rate. In certain circumstances, it is a two-edged weapon for the surgeon: either other procedures can be combined with it or it can be combined with other procedures depending upon the primary goal of treatment, for example, biopsy of tectal, thalamic, and pineal tumors and excision of intraventricular tumors. It acts as a temporary palliative option for tumors like cerebellopontine angle tumors and medulloblastomas. Recent studies have shown encouraging results in cases previously considered to be un-optimal/suboptimal for ETV, like communicating hydrocephalus and far distal obstruction. However, in infants the validity needs to be tested in the long term. In experienced hands with proper precautions, perioperative complications can be kept at minimum. Wherever possible, in cases of obstructive hydrocephalus, especially in patients >1 year of age, ETV should be the option of choice. We recommend a proper case selection, including preoperative detailed reading of sagittal MRI scan, to improve the success rate.

Conflict of Interest
None declared.
References

1. Oertel MK, Csokonay A. Presentation of the success rate of ETV in distinct indication cases of hydrocephalus. http://dx.doi.org/10.5772/intechopen.72889