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Original Research Article

# ANAESTHESIA FOR ENDOSCOPIC THIRD VENTRICULOSTOMY: A UNICENTRIC RETROSPECTIVE STUDY OF 34 CASES

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ABSTRACT

**Background:** Neuroendoscopy, the minimally-invasive access to the brain via endoscope and the endoscopic third ventriculostomy (ETV) have gained popularity in neurosurgery, almost replacing standard procedures for many treatable neurosurgical disorders as ventriculoperitoneal (VP) shunt treatment of obstructive hydrocephalus minimal damage to healthy brain tissue. Procedures for access to third ventricle require well-maintained surgical plane of general anaesthesia, warranting constant surveillance and dynamic management which is discussed herein.

**Materials and Methods:** 34 patients (Infant, Children, Adults) underwent ETV surgeries in 2 years from August 2017 to May 2019 in Jawaharlal Nehru Medical College Hospital, AMU, Aligarh. Patients were studied for peri-operative measures, especially anaesthetic techniques and incidence of complications with its timely management. Patients' demographic data, duration of the procedure, anaesthetic drugs used, amount of irrigation fluid used, blood loss, haemodynamic variations, perioperative biochemical analysis, and complications were diligently recorded and analysed.

**Results:** The majority were treated for obstructive hydrocephalus, indications for ETV in our study were hydrocephalus due to posterior fossa tumors or intraventricular tumor or cysts, previous ventriculitis, Chiari malformation, failure of ventriculoperitoneal shunting, congenital fourth ventricular outlet obstruction. Mean age for infants was 7.9 month (19.35% of total patients), for children 9.7 years (32.25 %) and mean age for adults was 39 years (41.93%) (range 18-60 years). Duration of surgery for ETV ranged from 40 minutes to 1.5 hours depending on aetiology, mean operation time was found to be 1. 1±s.d hours, and for ETR (endoscopic tumour resection) the operating time was ranged 3.0 - 5.5 hrs. Intravenous infusion of lactated ringer was used for brain irrigation during endoscopy or ETV. The mean fluid volume for irrigation in ETV was 0.5-1 L and for ETR was 4.0-5.0 L. Intra-operative complications occurred only in few patients, were mostly related to a cardiovascular response as cardiac arrhythmia either tachycardia followed by hypertension or bradycardia without hypertension requiring immediate management. Minor bleeding obscured the vision of the endoscope was encountered in 2 patients (0.49%) due to injury to branches of the basilar artery or large ependymal veins. Intraoperative bradycardia, tachycardia and hypertension were the common haemodynamic changes, noted during the procedure. No post-operative complication was observed and there was no peri-operative mortality in any patient.

**Conclusion:** Our 18% patients were within one year of age, required meticulous technique and constant vigilance during perioperative period. Anesthesiologist should always be alert for intra and postoperative

complications secondary to ETV and immediately respond and warn the surgeon accordingly. Though the procedure is a minimally invasive, close observation of vital signs, serum electrolytes as well as volume and temperature of the irrigation fluid should be done. The close communication between anesthesiologist and surgeon, are prerequisites for better outcome.
**Keywords:** Endoscopic third ventriculostomy (ETV), anaesthetic management, Neuroendoscopy, perioperative management, complications

## INTRODUCTION

Endoscopic procedures have gained popularity in neurosurgery, almost replacing the standard ventriculoperitoneal (VP) shunt surgeries. Neuroendoscopy, almost exclusively performed initially for endoscopic third ventriculostomy (ETV) for the treatment of obstructive hydrocephalus, is now frequently used for the management of all types of neurosurgically treatable disorders.[1]

Endoscopic third ventriculostomy (ETV) allows intracranial intervention with minimal damage to healthy brain tissue. Also from the surgeon's perspective, it provides better visualization of the intracranial structures. Victor Lespinasse is credited to have performed the first endoscopic procedure in neurosurgery about 100 years ago. He used a cystoscope to fulgurate the choroid plexus in two infants.[2] Twelve years later, Walter Dandy repeated the same procedure.[3]

Endoscopic third ventriculostomy (ETV) has become the standard therapeutic procedure for non-communicating hydrocephalus,[4] quick, simple, minimally invasive procedure with less morbidity and mortality compared to standard ventriculoperitoneal (VP) shunt placement.[5] Surgical manipulation of cerebral structures can severely disturb intracranial pressure, cerebral perfusion and oxygenation. This alteration of cerebral homeostasis may predispose important risks for irreversible brain damage, and haemodynamic instability. A proper understanding of the physiological changes during these procedures is essential for optimal patient care.

Though neuroendoscopy has been successfully used for third ventriculostomy, tumour biopsy or resection, cyst fenestration or removal, evacuation of intraventricular haemorrhage and plexus coagulation, it is commonly used in the management of non-communicating hydrocephalus.[6]

Procedure often requires a general anaesthesia and necessitates manipulation of the brain to access the floor of the third ventricle and increase the flow of cerebrospinal fluid. As literature on perioperative management of ETV is limited provision of anaesthesia is challenging. This article is a retrospective study of 34 cases of ETV operated in the Neurosurgery department of Jawaharlal Nehru Medical College, Aligarh. Thrust of this study is comprehensive anaesthetic techniques, intraoperative management and incidence and management of complications.

## MATERIALS AND METHODS

Following approval from Ethics Committee of Jawaharlal Nehru Medical College Hospital, AMU; ETV surgeries performed in period b/w 2017-2020, were retrospectively studied for pre-operative, intra-operative and post-operative variables. Data collection for each case consisted of age, sex, preoperative biochemical analysis, duration of the procedure, anaesthetic drugs used, amount of irrigation fluid used, blood loss, haemodynamic variations, postoperative biochemical analysis and perioperative complications. Patients of all age were included in the study.

**Patients Selection:** Patients undergoing elective and emergency neuroendoscopic surgery for the treatment of hydrocephalus and other intraventricular pathology operated by the same neurosurgical team were studied. Informed consent was obtained for every procedure. The diagnosis of obstructive hydrocephalus was based on clinical features besides signs and symptoms of raised intracranial pressure. Moreover, the diagnosis was confirmed with CT brain. Patients with anaemia, electrolyte imbalance, hormonal dysfunction, or cardiovascular or respiratory system problems, were excluded from the study.

**Surgical Procedure:** Basically, ETV involves establishing a connection between third ventricle and pre-pontine subarachnoid space, fenestrating the floor of third ventricle. This allows the flow of cerebrospinal fluid (CSF) from the third ventricle to basal subarachnoid space while bypassing the aqueduct. Absolutely still the patient is required for the safe passage of scope through the brain tissue. Adequate analgesia is achieved with infilteration of local anaesthetics with adrenaline, which prevents bleeding as well.

During neuroendoscopy, the patient is positioned supine with the head elevated to 20°–30° and neck slightly flexed. A bur hole is drilled at point, about 3 cm from the midline and 1 cm anterior to the coronal suture, known as Kocher's point. A rigid neuroendoscope (Karl Storz) with a working port (6-mm sheath), and a telescope (1.8-mm), is introduced into the lateral ventricle [Figure 1]. Continuous irrigation with Hartmann's solution is initially started at 5–10 ml/min and the irrigation speed can be increased if required. To keep the third ventricle slightly overfilled, irrigate for a 10-15s without letting the fluid out. The irrigation to be monitored in the drip chamber. When it slows or spontaneously stops, it is assumed that the third ventricle is overfilled and fluid should be released through the sheath. The endoscope is advanced through the foramen of Monroe into the cavity of the third ventricle, where fenestration is planned. After ventriculoscope insertion, the procedure can be viewed on a video screen. The ventricular floor is identified as a bluish transparent membrane in front of the mammillary bodies [Figure 2]. Basilar artery pulsations are seen on careful observation. Perforation of the third ventricle floor is performed [Figure 3] with sustained pressure on the membrane by long third ventriculostomy forceps in the midline between the infundibular recess and the mammillary bodies [Figure 4]. The opening was dilated to 5–6 mm with a 3-Fr Fogarty balloon catheter. Adequacy of the ventriculostomy was judged by oscillations of CSF flow through the fenestration.[7] Usual surgical time is 20–60 min.

**Anesthetic Management:** The goals of anaesthetic management include intraoperative immobilization, cardiovascular stability, and rapid emergence for early neurological examination. Sudden increases in intracranial pressure must be monitored and treated immediately. Therefore, adequate monitoring and good communication with the neurosurgeons is essential.

**Preoperative assessment:** In emergency, patients may present with symptoms of elevated intracranial pressure (ICP) such as vomiting, headache, lethargy, confusion, obtundation or stupor. They may have history of prior shunt placements with existing shunt tubing. Dehydration or electrolyte abnormalities may be present due to prolonged nausea and vomiting, if present are to be corrected before surgery. The patient's neurological status and examination should has to be documented. Hydrocephalus, often being associated with multi-system congenital syndromes, necessitates evaluation and optimization by concerned speciality.

**Induction and maintenance:** The monitoring applied was ECG, pulse oximetry and non invasive blood pressure (NIBP) and temperature probe to maintain the optimal temperature. The children premedicated in the operating theatre only and the anaesthetic drugs were prepared and titrated very carefully.The intravenous cannulation was started under inhalation induction sevoflurane anaesthesia. Sevoflurane is superior to other inhalational agents in paediatrics because of its well-tolerated odour which facilitates smooth induction, less incidence of laryngospasm, airway irritability, and breath holding compared to isoflurane. Preoxygenation was started with 100% oxygen. The premedication includes injection dexamethasone 0.2 mg/kg (to reduce brain swelling ) inj. glycopyrrale 0.01 mg/kg (inj atropine 0.02mg/kg in infant <6 month old), inj midazolam 0.02 mg/kg and fentanyl 01 mcg/kg. Induction was achieved either with inj. thiopentone 3-5mg/kg or propofol 1–2 mg/kg and tracheal intubation was facilitated with inj. atracurium 0.2 to 0.3 mg/kg or cistracurium 0.5mg/kg. The patients were ventilated with an oxygen–air mixture ( O2 40%) to achieve an end-tidal CO2 between 30 and 35 mm Hg. The use of nitrous oxide is discouraged owing to ICP elevation, expansion of ventricular air bubbles and exacerbation of symptoms in the event of venous air embolism.[6,8,9] For maintenance of anaesthesia either total IV anaesthesia (TIVA) with propofol and fentanyl or volatile agents like sevoflurane may be used. High dose narcotics which can cause prolonged postoperative sedation was avoided as rapid postoperative neurological assessment is desirable.

Inhalational agents were safe in <1 minimum alveolar concentration (MAC) to avoid increase in cerebral blood flow (CBF). Care of thermoregulation was done, especially in small infants and small children. Large exchange of irrigation fluid and wetting of surgical drapes expose the child to the risk of life threatening perioperative hypothermia.[10] We use the thermal blanket, warm irrigation fluids and fluid warmer during perioperative period. During procedure normovolaemia was maintained with IV fluid administration and blood transfusions was not required.

Postoperative nausea and vomiting (PONV) prophylaxis was advised because raised ICP often leads to increased gastric acid secretion, and further increases the risk of vomiting. Prophylactic analgesics, usually a combination of low dose opiates and paracetamol in most cases provides adequate analgesic effect without affecting neurological recovery. Non-steroidal anti-inflammatory drugs are generally discouraged because of haemostatic concerns.

Intraoperative Monitoring: Close monitoring of oxygenation, circulation, and intracranial pressure is important. Apart from standard ASA monitoring viz, Pulse rate (PR), Non-invasive BP(NIBP), electrocardiography(ECG), Temperature, End- tidal CO2 (Etco2), invasive blood pressure(IBP) monitoring by an indwelling arterial catheter was also recommended.Beat-to-beat monitoring of the arterial blood pressure offers the most reliable warning sign for a developing Cushing reflex, which is a sign of decreased Cerebral Perfusion Pressure (CPP) which the mean arterial pressure minus intracranial pressure.[16] The CPP should be maintained above 40mmHg. Transcranial doppler is the fastest and most reliable method to show abrupt decreases in cerebral blood flow due to increased ICP.[17] Because of its high sensitivity to impaired cerebral blood flow, it may be considered as basic monitoring, although practical objections limit its routine use during neuroendoscopy. Continuous measurement of the ICP is also suggested. Active rinsing of the ventricles can unexpectedly increase the ICP very drastically. The principal reasons for induced intracranial hypertension is high flow rinsing and obstruction of the outflow channel by tissue debris, blood clots or kinking of outflow tubes. Thus increases in ICP must be detected as soon as possible to prevent severe complications such as cardiovascular instability,[11,12] herniation syndromes, retinal bleeding,[13,14] and excessive fluid resorption.[15] Changes in heart rate in the form of bradycardia or tachycardia was defined as decreases or increases in heart rate (HR) below or above the 20% from baseline values respectively. Hypertension or Hypotension was defined as alteration in MAP above or below the 20% from baseline values respectively. Hemodynamic variations were to be treated initially by retraction of the associated surgical maneuver, and if persistent, drug treatment was to be given.

## RESULTS

In our study total of 34 patients were analyzed during this 5 yrs period. There were 15 male and 19 female. Demography, patient and surgical details were given in [Table 1]. Majority of patients were treated for obstructive hydrocephalus. Other indications for ETV were hydrocephalus due to posterior fossa tumors or cysts, previous ventriculitis, posterior fossa hemorrhage, Chiari malformation, failure of ventriculoperitoneal shunting, congenital fourth ventricular outlet obstruction, and empty sella syndrome. [Table 2]. The duration of surgery ranged from 40 minutes to 2 hours. Duration was measured from skin incision until skin closure. The very short procedures were operations in children with open anterior fontanelles in which the lateral aspect of the fontanelle was used to access the ventricle without the need for a bur hole was uneventful in our case report. This happened in few cases. The shortest time recorded in only 2 cases. Intraoperative tachycardia occurred in 4 patients (where heart rate was above 150 beats./min), and was accompanied by mild hypertension. Bradycardia was observed in 6 patients of whom only 2 patients had accompanying hypertension. In total the hypertension was noted in 6 patients associated with either bradycardia or tachycardia. Thus in total, 29.41% of patients had transient intraoperative cardiovascular instability in the form of hypertension with arrythmias. When the surgeon was alerted to the event, surgery was paused and maneuvers such as releasing irrigation fluid, deflating the balloon, or withdrawing the endoscope resulted in prompt normalization of observed hemodynamic changes. All hemodynamic changes were transient, no drug treatment was required, and there was no postoperative morbidity related to these changes. No patient suffered an intraoperative cardiac arrest. No major bleeding was encountered in our study cases during third ventriculostomy endoscopy. Bleeding mostly occurs either injury to branches of the basilar artery or large ependymal veins. In the late postoperative period, four children (12.5%) had vomiting, one had (3.1 %) seizures were managed properly.

**Table 1: Age and sex distribution of 34 patients.**

| Variables | No. of Male /and Female | No.of patients |
|---|---|---|
| Infants (>6 month) | 4/2 | 6 |
| 1-5 years | 3/2 | 5 |
| Children 5-15 year | 3/5 | 8 |
| Adult | 5/10 | 15 |

**Table 2: Indications For ETV In 34 patients.**

| | |
|---|---|
| Hydrocephalus due to cysts | 8 |
| Aqueductal stenosis Hydrocephalus | 2 |
| Hydrocephalus due to posterior fossa tumors | 5 |
| Previous ventriculitis/ abscess | 5 |
| Failure of ventriculoperitoneal shunt | 3 |
| Hydrocephalus due to hemangioma | 1 |
| Hydrocephalus due to Chiari malformation | 1 |
| Hydrocephalus empty sella syndrome/pituitary adenoma | 2 |
| Congenital fourth ventricular outflow obstruction | 7 |

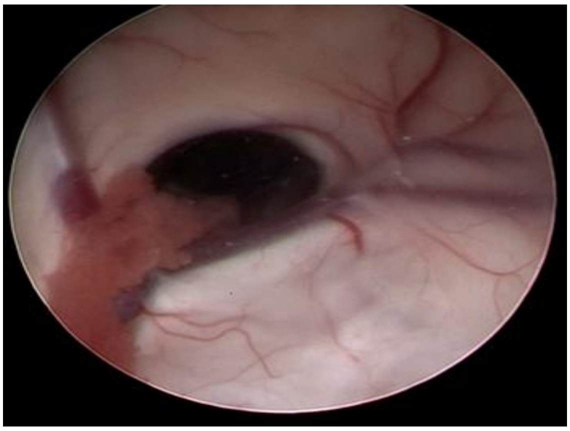
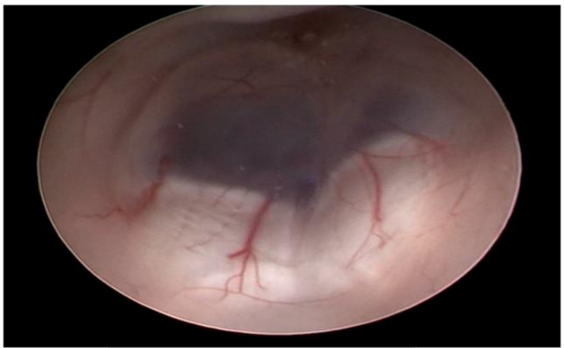


**Figure 1: Choroid Plexus and Foramen of Monro**



Mammillary bodies

**Figure 2: Vetricular Floor identified with the help of Mammillary Bodies**

**Figure 3: Fogarty balloon catheter inserted through hole**

**Figure 4: Endoscope withdrawn with uninjured column of Fornix**

## DISCUSSION

Age should not be considered a limitation to the procedure. Some authors defend the idea that children less than 6 months-old are not eligible candidates for the procedure due to the high rate of failure involved.[9,13]

Although these procedures have been routine since last 2 decades, the reports in the literature on anaesthesia in children undergoing neuroendoscopic surgeries are rare.[5,6] Among the techniques employed, third ventriculostomy has been used frequently in the treatment of obstructive hydrocephalus, found in increasing numbers in premature infants or in children with other severe diseases, because it eliminates the need for ventriculo-peritoneal derivations.[2,7]

As anaesthesia for ETV procedure differs in many ways from conventional neurosurgical operations, anaesthesiologists are faced with the perioperative requirements and risks of this popular procedure. Intraoperative hemodynamic changes during ETV have been extensively studied with conflicting results. In a previous study, tachycardia was found to be more frequent than bradycardia and was attributed to an increase in intracranial pressure (ICP) and systemic hypertension. Obviously increasing ICP indefinitely may lead to cardiac arrest and bradycardia may be one of the first indicators of impending cardiac arrest during ETV. Leach et al. reported a profound bradycardia leading to a short-lived, spontaneously resolving episode of asystole in two occasions during ETV.

However, despite being a minimally invasive technique, with low morbidity and mortality, it is not devoid of perioperative complications and the anesthesiologist should be knowledgeable on such matters.[5,6,8-18]

There are very few reports in the literature on neuroendoscopic procedures in children.[5,6] A consensus on monitoring has not yet been achieved. Recommendations on blood pressure monitoring vary whether non-invasive or invasive.[8] The invasive BP monitoring for complicated cases,[5] and non-invasive for every procedure.[6,9,10] With increased experience and knowledge of the possible complications, the anaesthetic conduct has changed toward more invasive monitoring, similar to any neurosurgical procedure in adults and in children,[6,9,15] especially in more complex neuroendoscopic procedures (tumor biopsy, cyst fenestration, etc) or when there is a change in the anatomy.

Neuroanaesthesia conduct and technique used in children are different from those used in adults. Despite knowing the negative effects of high concentrations of volatile anaesthetics under pressure on brain perfusion, several authors agree that inhalational induction should be used in children without venous access or when the use of pre-anaesthetic medication is contraindicated.[5,11-26]

There is also no consensus on the most suitable maintenance technique. Total venous anaesthesia, inhalational anaesthesia, or combined anaesthesia, which demand that the anaesthesiologist be aware of the possible adverse effects that such techniques might pose on cerebral haemodynamics and their implications in patients with increased intracranial pressure, are mentioned.[5]

In a recent study undertaken in Turkey with 210 children, 40% of them developed intraoperative cardiac arrhythmias.[6] Besides tachycardia, there are reports in the literature of bradycardia, several cardiac arrhythmias, hypotension, hypertension, and even cardiac arrest.[8,9,12,13,17] All these events might occur after manipulating one of the delicate structures around the third ventricle (hypothalamus, brain stem). Besides direct stimulation, the causes may vary from a reduction in brain perfusion to ischemia of those structures secondary to an increase in intracranial pressure. Most are short-term changes, returning to normal parameters as soon as the balloon of the Fogarty catheter is deflated, the ventriculoscope is removed, and intracranial pressure returns to normal.[6,8]

Venous or arterial bleeding is the most feared complication. The basilar artery is located under the floor of the third ventricle, being subjected to trauma by the catheter,[1-6,15] which many times leads to the placement of an external ventricular derivation. In this study, this happened to one of the patients due to bleeding of the perforating arteries. It can also be an indication to change the procedure to open craniotomy to eliminate the bleeding.[10] Besides those complications, there are reports in the literature of: diabetes insipidus, syndrome of inappropriate antidiuretic hormone secretion, paralysis of cranial nerves, especially III and VI, delayed awakening, transitory mental confusion, loss of memory, infection, hemorrhage, seizures, headache, pneumocephalus, and cardiorespiratory arrest.[8-10,17] Most postoperative complications observed were not related specifically to the procedure, such as vomiting and respiratory problems.

Intraoperative hemodynamic changes during ETV have been extensively studied with conflicting results. On one study tachycardia was found more frequently than bradycardia and was attributed to an increase in intracranial pressure (ICP) and systemic hypertension and was caused by high-speed fluid irrigation or kinking of the outflow tube.Kalmar and Van Aken,[15] Atypical Cushing response was given to explain the frequency of tachycardia during ETV. The classic response as described by Cushing includes apnea, hypertension and bradycardia. However, in the literature tachycardia consistently preceded bradycardia in the Cushing response and was attributed to compression of hypothalamus by dilated third ventricle.[16,17] Baykan et al, reported bradycardia intraoperatively alone in 28.1% and the respective rates for asystole and for bradycardia following tachycardia as 0.5% and 12.4% with an overall incidence of arrhythmia involving bradycardias as 41%.[14] Derbent et al, encountered bradycardia in only 1 of the 24 patients for a short period during balloon inflation with possible temporary brain stem ischemia and subsequent bradycardia.[8] Bradycardia may be one of the first indicators of impending cardiac arrest during ETV which can be easily treated by pulling the scope away from the floor of the third ventricle.[20] Leach et al,[21] reported in two occasions during ETV a profound bradycardia leading to short-lived, spontaneously resolving episode of asystole. Both patients, in their series of over 210 patients, awoke unharmed. On both these occasions, it was noted that the event followed irrigation, not routinely used in their practice, and the irrigation fluid was at room temperature. Therefore, they advocated that if irrigation is to be used, care should be taken to keep the fluid strictly at body temperature and prophylactic anticholinergic glycopyrrolate 0.4 mg to be given at induction.[21]

Another issue of interest following ETV is the postoperative electrolytes imbalance. Postoperative hyperkalemia has been reported following ETV.[6] The authors attributed hyperkalemia to a disturbance related to the hypothalamic nuclei situated in the floor of the third ventricle. However, the hyperkalemic response in these patients has been noticed in isolation, without any change in the serum sodium level. Also it was transient and late in onset which suggests a hormonal dysfunction. In that report we found that the authors were using lactated ringer solution for irrigation, which we believe has contributed to the hyperkalemic response following ETV. Derbent et al, reported that although they were using lactated ringer solution for irrigation and 0.9% normal saline for intravenous fluid replacement during ETV, there was no significant difference between the pre and postoperative serum sodium and potassium.[19] Van Aken et al, noted that when normal saline is used for irrigation during ETV, hypertension and reflex bradycardia occurred and they recommend use of lactated ringer solution instead.[15]

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## CONCLUSION

Endoscopic third ventriculostomy (ETV) though standard therapeutic procedure for non-communicating hydrocephalus, often requires general anaesthesia and necessitates manipulation of the brain. With limited literature on perioperative management of ETV, provision of anaesthesia becomes challenging. This study though small in size, offers an insight into anaesthetic management and perioperative complications in ETV surgery.

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