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RESEARCH ARTICLE

# CLINICAL ANALYSIS AND ROLE OF ENDOSCOPIC THIRD VENTRICULOSTOMY FOR OBSTRUCTIVE HYDROCEPHALUS IN INFANTS - A PROSPECTIVE STUDY

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**ABSTRACT**

**Background:** Endoscopic third ventriculostomy is increasingly used in the treatment of hydrocephalus. It is considered treatment of choice in obstructive hydrocephalus. There are varying opinions about results of ETV in infants. We therefore prospectively studied the outcome of endoscopic third ventriculostomy in infants with obstructive hydrocephalus.

**Aim:** To investigate the outcome of endoscopic third ventriculostomy in infants with obstructive hydrocephalus.

**Methods & Materials:** A prospective study of 34 infants undergoing ETV in our institution from July 2013 to December 2015 was carried out. Obstruction was revealed by preoperative computed tomographic scan and magnetic resonace imaging. The etiology of obstructive hydrocephalus was congenital aqueductal stenosis in twenty five patients, posthemorrhagic obstruction in two patients and postinfection etiology in seven patients. The results of ETV were determined by assessing clinical signs of raised intracranial pressure, head circumference measurements and fontanelle tension, as well as by MRI / CT scans and post operative CSF flow studies. ETV was considered successful if a patient showed clinical evidence of normal intracranial pressure and structural evidence of stable or decreased ventricular size whereas was considered failure in cases in which a patient showed no change in clinical symptoms or requires placement of a shunt within days or months of the procedure.

**Results:** ETV was successful in 28 patients with a mean follow up period of 14.6 months. Successful procedure was noted in 88% patients with aqueductal stenosis, 50% with posthaemorrhagic and 71.4% with postinfective obstructive hydrocephalus. In 6 patients ETV was considered failure. These patients required a shunt. Out of 6 patients with failure, five of them were less than 6 months old when ETV was performed and four of them were low birth weight pre mature infants. Overall success rate was 82.3% in infants with obstructive hydrocephalus.

**Conclusion:** ETV is a better alternative surgical treatment to shunt surgery for obstructive hydrocephalus in infants. Its fairly safe and effective. Posthaemorrhagic and Postinfective obstructive hydrocephalus have more failure rate as compared to congenital obstructive hydrocephalus due to aqueductal stenosis. Efficacy of ETV was better in full term normal birth weight infant as compared to low birth weight pre mature infants.



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## INTRODUCTION

Endoscopic techniques are being increasingly used in the management of various neurosurgical pathologies in recent times. (Yadav *et al*., 2012; Yadav *et al*., 2011; Yadav *et al*., 2010; Yadav *et al*., 2008; Yadav *et al*., 2010) Deep seated pathology in the intracranial compartment can provide a difficult challenge to the neurosurgeon. Advances in endoscopic technology and miniaturization of surgical instrumentations have expanded the application of neuroendoscopy. Justifiably, endoscopic third ventriculostomy (ETV) is considered the greatest breakthrough in the management of obstructive hydrocephalus. (Van Beijnum *et al*., 2008; Mohanty *et al*., 2011; Morgenstern *et al*., 2011) Currently ETV is the first choice for obstructive hydrocephalus because of the quality of endoscopic instruments and advances in imaging techniques, it has yielded excellent results and can

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render a large number of patients shunt-independent. (Al-Tamimi *et al*., 2008; Oppido *et al*., 2011; Roopesh Kumar *et al*., 2007) Few studies report poor success rate in infants as compared to older patients. (Buxton *et al*., 1998; Goumnerova and Frim, 1997; Hopf *et al*., 1999; Jones *et al*., 1994) We therefore prospectively studied the outcome of endoscopic third ventriculostomy in infants with obstructive hydrocephalus.

## MATERIALS AND METHODS

A prospective study of 34 infants undergoing ETV in our institution from July 2013 to December 2015 was carried out.

**Inclusion criteria**

i. Infant
ii. Obstructive Hydrocephalus
iii. Normal or collapsed fourth ventricle

**Exclusion criteria**

i. History of previous CSF diversion procedure
ii. Associated myelomeningocele (Arnold Chiari Malformation – Type II)
iii. Patients who lost follow up

Obstruction was revealed by preoperative computed tomographic scan or magnetic resonance imaging. The etiology of obstructive hydrocephalus was congenital aqueductal stenosis in twenty five patients, posthemorrhagic obstruction in two patients and postinfection etiology in seven patients. The results of ETV were determined by assessing clinical signs of raised intracranial pressure, head circumference measurements and fontanelle tension, as well as by MRI / CT scans and post operative CSF flow studies. ETV was considered successful if a patient showed clinical evidence of normal intracranial pressure and structural evidence of stable or decreased ventricular size whereas was considered failure in cases in which a patient showed no change in clinical symptoms or requires placement of a shunt within days or months of the procedure.

**Statistical Analysis**

Categorial data were expressed as rates, ratios and percentages and comparision was done using chi-square test. Continuous data was expressed as mean ± standard deviation.

## RESULTS

A total of 34 infants who underwent ETV in our institution from July 2013 to December 2015 were included in our prospective analysis. Age, gender, clinical features, aetiology, radiological features and surgical outcome were considered for analysis. The result of the study was analysed by appropriate statistical tool. The mean follow up period was 14.6 months. The results of the study are as follows. The age of the patient ranged from 18 days to 356 days. 65% of patients were below 6 months of age. The mean age was 146.6 days and median age was 131 days. 59% of patients were male and 41% were females. There was no gender predilection but slight male preponderance.

**Table 1. Clinical Features**

| Symptoms | Percentage | Signs | Percentage |
|---|---|---|---|
| Rapid increase in head size | 88% | Increase in head circumference | 94% |
| Downward deviation of eye | 68% | Sunset sign | 74% |
| Vomiting | 38% | Cranial nerve deficit | 68% |
| Excessive sleep | 35% | Altered sensorium | 41% |
| Poor feeding | 21% | Papilloedema | 59% |
| Seizure | 09% | Bulging anterior fontanelle | 71% |

Obstruction was revealed by preoperative computed tomographic scan and magnetic resonance imaging. The etiology of obstructive hydrocephalus was congenital aqueductal stenosis in twenty five patients, posthemorrhagic obstruction in two patients and postinfection etiology in seven patients. The results of ETV were determined by assessing clinical signs of raised intracranial pressure, head circumference measurements and fontanelle tension, as well as by MRI / CT scans and post operative CSF flow studies. ETV was considered successful if a patient showed clinical evidence of normal intracranial pressure and structural evidence of stable or decreased ventricular size whereas was considered failure in cases in which a patient showed no change in clinical symptoms or requires placement of a shunt within days or months of the procedure. ETV was successful in 28 patients with a mean follow up period of 14.6 months. Successful procedure was noted in 88% patients with aqueductal stenosis, 50% with posthaemorrhagic and 71.4% with postinfective obstructive hydrocephalus. In 6 patients ETV was considered failure. These patients required a shunt. Out of 6 patients with failure, five of them were less than 6 months old when ETV was performed and four of them were low birth weight pre mature infants. Overall success rate was 82.3% in infants with obstructive hydrocephalus.

**Table 2. ETV outcome**

| Aetiology | Successful ETV | Age (Days) | Successful ETV |
|---|---|---|---|
| Aquductal Stenosis | 88% | 0 – 90 | 77% |
| Posthaemorrhagic | 50% | 91 – 180 | 78% |
| Postinfective | 71.4% | 181 and above | 92% |
| P > 0.05 | | P > 0.05 | |
| Gestational period and Birth weight | Successful ETV | Sex | Successful ETV |
| Full term normal birth weight | 93% | Male | 80% |
| Pre mature low birth weight | 20% | Female | 86% |
| P < 0.05 (Significant Statistically) | | P > 0.05 | |

Following ETV few complications were associated. 15% patients had infection, 30% had CSF leak, 3% had intraoperative haemorrhage and 18% had subdural fluid collection. 1 patient died following ETV due to pneumonia.

## DISCUSSION

Endoscopic Third Ventriculostomy (ETV) is considered as treatment of choice for obstructive hydrocephalus. (Zohdi *et al*., 2013) It is indicated in hydrocephalus secondary to congenital aqueductal stenosis, posterior third ventricle tumor, cerebellar infarct, Dandy-Walker malformation, vein of Galen aneurism, syringomyelia with or without Chiari malformation type I, intraventricular hematoma, post infective, normal pressure hydrocephalus, myelomeningocele, multiloculated hydrocephalus, encephalocele, posterior fossa tumor and craniosynostosis. It is also indicated in block shunt or slit ventricle syndrome. (Yadav *et al*., 2012) Ventriculoscopy was introduced in early 1900s. Walter E. Dandy performed choroid plexectomy using a primitive endoscope for communicating hydrocephalus. He later modified and introduced the sub-frontal approach for an open third ventriculostomy but was associated with high morbidity and mortality. Later in 1910, V. L. L'Espinasse, an urologist, attempted endoscopic management for hydrocephalus using cystoscope to cauterize choroid plexus. Further in 1923, William Mixter was the first one to perform ETV in a child with obstructive hydrocephalus using an urethroscope. Further necessary modification in this urethroscope was done by Tracy J. Putnam for cauterization of the choroid plexus. In 1947, H. F. McNickle introduced a percutaneous method of performing third ventriculostomy that decreased the complication rate and improved the success rate. In the early 1970s, the leukotome was introduced to enlarge the perforation in third ventricle floor without an injury to the surrounding vascular structures. This was further supported by an advent of advanced fiber optic and lens technology. We now have small neuroendoscopes with deflectable tips, working ports, and good optic resolution, in addition to the rigid endoscopes with their excellent optic resolution. High definition camera has further improved visualizing and recording. An improvement in the success of third ventriculostomy in recent time could be due to better patient selection; improvements in endoscope, better imaging, advanced surgical technique and instruments. (Yadav *et al*., 2012) In endoscopic third ventriculostomy, a small perforation is made in the thinned floor of the third ventricle, allowing movement of cerebrospinal fluid (CSF) out of the blocked ventricular system and into the interpenducular cistern. Cerebrospinal fluid within the ventricle is thus diverted elsewhere in an attempt to bypass an obstruction in the aqueduct of Sylvius and thereby relieve pressure. The objective of this procedure, called an "intracranial CSF diversion," is to normalize pressure on the brain without using a shunt. Endoscopic third ventriculostomy is not a cure for hydrocephalus, but rather an alternate treatment. Although open ventriculostomies were performed as early as 1922, they became a less common method of treating hydrocephalus in the 1960s, with the advent of shunt systems. Shunt placement, due to its effectiveness in early post operative period, has become widespread method of treating both obstructive and non obstructive hydrocephalus. However, the high frequency and seriousness of post operative complications lead to a significant decrease in quality of patients life. The ultimate goal of endoscopic third ventriculostomy is to render a shunt unnecessary. Although endoscopic third ventriculostomy is ideally a one-time procedure, evidence suggests that some patients will require more than one surgery to maintain adequate opening and drainage. (Mohanty *et al*., 2002) The clinical success rate of ETV in our study was 82.3%. These results are comparable to other studies. Success rate of 83.7% (Yadav YR *et al*.), 71% (Javadpour M *et al*.), 64% (Gorayeb RB *et al*.) and 85% (Buxton N *et al*.) was observed in other studies done in infants.(12,18-20) In our study, about 77% patients below 6 months had successful ETV whereas success rate was about 92% in patients above 6 months old.

Kadrian *et al*. reported a strong effect of patient age on outcome. They reported that the success rate of ETV in infants younger than one month was extremely low. The maximum observed reliability of ETV in his study was 3.5 years. (Kadrian *et al*., 2008) Javadpour *et al*. reported success rate of 33% and found that success depend on aetiology rather than on patients age. (Javadpour *et al*., 2001) The largest study of ETV success involving 153 infants was conducted in Uganda. (Warf, 2005) The success rate was 53%. The surgery success rate for patients with aqueductal stenosis was 70% which in our case was 88%. This difference may be due to small sample size in our case. Y R Yadav *et al*. and Baldauf *et al*. are the most similar studies to ours. (Yadav *et al*., 2006; Baldauf *et al*., 2007) The mean age in our study was 146.6 days whereas it was 6.7 months in Baldauf *et al*. series. Y R Yadav *et al*. reported overall success rate of 83.3% with a mean follow-up period of 18 months. Baldauf *et al*. reported overall success rate of 43% with a mean follow-up period of 26.2 months. In our study overall ETV success rate was 82.3% with a mean follow-up period of 14.6 months. Clinical success rate of ETV in congenital aqueductal stenosis in Y R Yadav *et al*, Baldauf *et al* and our study was reported as 84.5%, 50% and 88% respectively. Whereas in postinfective aetiology success rate reported by Y R Yadav *et al*, Singh *et al* and our study was 66.6%, 77% and 71.4% respectively. (Yadav *et al*., 2006; Singh *et al*., 2005) Jonathan *et al* reported long term successful results with ETV in both their cases with hydrocephalus secondary to TB meningitis. (Jonathan and Rajshekhar, 2005) These results are almost comparable to our study. Fritsch *et al*. reported clinical ETV success rate of 37%. (Fritsch *et al*., 2005) He concluded that ETV is an alternative surgical method for treatment of obstructive hydrocephalus in infants. They also concluded that success of ETV was determined by the aetiology of hydrocephalus and age does not present a contraindication or increase the perioperative risk. There are great debates regarding the success of ETV in infants. Some authors found that ETV success do not depend on age of the patient whereas aetiology, gestational age and birth weight have variable impact on the results. (Yadav *et al*., 2006; Lipina *et al*., 2008) Others reported poor results, especially in neonates and infants younger than 2 months. (Gallo *et al*., 2010; Drake, 2007) Shim *et al*. suggested that simultaneous ETV and ventriculo peritoneal shunt should be performed in infantile hydrocephalus due to poor results of ETV alone. (Shim *et al*., 2008) Kulkarni AV *et al*. reported the relative higher risk of initial failure in ETV, than shunt in children. (Kulkarni *et al*., 2010) The relative risk becomes progressively lower for ETV after about 3 months of age. Patient could experience a long term treatment survival advantage after an early high risk period of ETV failure as compared to shunt. To realize this benefit, it might take several years was concluded by them. Failure rate of ETV done in premature low birth weight infants as compared to full term normal birth weight infants was statistically significant. Failure rate of ETV in low birth weight pre mature infants was higher (80%) as compared to full term normal birth weight infants (7%) in our series which reported by Yadav YR *et al*. was 60% cases in low birth weight pre term infants and 12.3% cases in full term normal birth weight infants which are comparable. (Yadav *et al*., 2006) In our series, failure rate of ETV is 17.7% which reported by Yadav YR *et al*. was 16.7%. Overall complication rate after ETV is about 2% to 15%, but the permanent complications are few. (Yadav *et al*., 2012) However, complications such as fever, bleeding, hemiparesis, cranial nerve deficit, memory disorders, altered consciousness, chronic subdural haematoma, diabetes insipidus, weight gain and precocious puberty are reported. Intra operative neural injury such as thalamic, forniceal, hypothalamic and midbrain injuries are also reported. (Ersahin and Arslan, 2008; Bouras and Sgouros, 2011; Fritsch *et al*., 2007; Wiewrodt *et al*., 2008; Civelek *et al*., 2007) Intraoperative bradycardia and haemorrhages including fatal haemorrhage due to basilar artery rupture are also reported. (El-Dawlatly *et al*., 2002) Fatal haemorrhage due to basilar artery injury was noticed in one patient in our study. This patient died later due to ventilator associated pneumonia. Attempts to perforate ventricular floor can also lead to bleeding, especially in hydrocephalus following an infection and haemorrhage. Minor bleeding was noticed during the procedure in 6% patients which stopped with persistant irrigation which reported by Yadav *et al*., Hopf *et al*. and Choi *et al*. was about 8%, 5% and 3% of cases respectively in their series. (Hopf *et al*., 1999; Yadav *et al*., 2006; Choi *et al*., 1999) Infection was seen in 15% patients in our study. Other studies also reported infection as a common complication. Yadav *et al*., Gorayeb *et al*., Javadpour *et al*. and Buxton *et al*. reported 8%, 11%, 10% and 15% of patients developed infection respectively in their series. (Buxton *et al*., 1998; Yadav *et al*., 2006; Javadpour *et al*., 2001; Gorayeb *et al*., 2004) Stoma blockage resulting in ETV failure in our series was found in 17.7% patients who underwent ventriculoperitoneal shunt later. Intraoperative bleeding and infection following ETV was common cause for stoma blockage. Aspiration of clots and thorough irrigation of ventricular cavity should be done after bleeding is controlled which can reduce the possibility of stoma closure. (Yadav *et al*., 2006) CSF leak was other common complication reported. In our series, CSF leak was present in about 30% cases where as reported by Yadav *et al*., Schroeder HW *et al*. and Kwiek *et al*. was about 16%, 2% and 7% cases respectively. (Yadav *et al*., 2006; Schroeder *et al*., 2002; Kwiek *et al*., 2003) Most common cause of persistant CSF leak was failed ETV mainly due to stoma closure while temporary CSF leak was attributable to common cause like failure of closure of dura, thinned out scalp and thin cortical mantle with gross obstructive hydrocephalus.

Though the present study does not show any distinct advantages statistically of type of surgical procedure for obstructive hydrocephalus in infants, in the light of above results, it can be concluded that ETV as an alternative surgical treatment to ventriculo peritoneal shunt as a primary choice. This alternative helps children to be shunt independent and low rate of complication of ETV as compared to shunt surgeries gives a better quality of life. The prospective analysis of the efficacy of ETV in infants was the strength of our study. However, the sample size and the follow up period in the current study being relatively short, a larger study sample and a longer follow up study may be needed before any further conclusions can be made. To summarise, there is no universal treatment protocol for obstructive hydrocephalus in infants. Complications of ETV and shunt surgeries have frustrated surgeons since the inception of modern surgery. In the quest for a perfect technique, various techniques were introduced but none guaranteed zero failure. At last but not the least, we should try to outline a management for obstructive hydrocephalus in infants which will help us to achive a goal that includes better quality of life and less morbidity and mortality. We recommend that families be given the opportunity to decide whether ETV should be attempted or a ventriculoperitoneal shunt is directly applied.

**Conclusion**

ETV is a better alternative surgical treatment to shunt surgery for obstructive hydrocephalus in infants. Its fairly safe and effective. Posthaemorrhagic and Postinfective obstructive hydrocephalus have more failure rate as compared to congenital obstructive hydrocephalus due to aqueductal stenosis. Efficacy of ETV was better in full term normal birth weight infant as compared to low birth weight pre mature infants. As per literature, the fact that complication rates of ETV are lower as compared to ventriculo peritoneal shunt and has relatively better quality of life and less morbidity and mortality with ETV, we recommend parental counseling in guiding the families in decision making to perform ETV or shunt in the treatment of obstructive hydrocephalus in infants. A multicenter extended study with a higher number of cases and long follow up period and exchange of experience is suggested for better outcome.

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