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Comparison of Different Endoscopic Techniques for the Treatment of Hydrocephalus in Children

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ABSTRACT

AIM: To present a series of hydrocephalus cases treated with different endoscopic techniques, and to compare their surgical outcomes.

MATERIAL and METHODS: Sixty-one patients underwent endoscopic approach for treating hydrocephalus over a 5-year period. Forty-six patients were children. Three surgical techniques [i.e., endoscopic third ventriculostomy (ETV), ETV plus shunting, and simultaneous ETV plus aqueductoplasty] were used in these patients. Surgical results were statistically analyzed based on age, gender, and type of surgery.

RESULTS: Of the 46 children, 24 (52.17%) were female with a mean age of 25.33 months. Twenty-one (45.65%) children underwent ETV alone, 19 underwent ETV plus ventriculoperitoneal shunting, and six underwent simultaneous ETV plus aqueductoplasty. Five (10.87%) children died during the follow-up period. No correlation was observed between surgery type and patient age. No statistically significant differences in sex and complications were found between the surgical techniques.

CONCLUSION: ETV alone is the safest method for treating hydrocephalus in children. Mortality is higher in patients younger than 12 months who underwent combined surgical methods, instead of ETV alone.

KEYWORDS: Hydrocephalus, Children, Endoscopic third ventriculostomy, Shunt, Aqueductoplasty

INTRODUCTION

Hydrocephalus can be defined as the abnormal accumulation of cerebrospinal fluid (CSF) within the ventricles. In the pediatric population, it is characterized by an initial increase in intraventricular pressure, resulting in abnormal dilation of the cerebral ventricles (14,16,19). The main cause of hydrocephalus is the disturbance of CSF formation, flow, or absorption (24). An increase in head circumference is mostly observed in children, whereas symptoms of increased intracranial pressure are frequent in adults (9). For many years, the only treatment for hydrocephalus was the insertion of a shunt system, and shunt placement is the most common procedure performed by pediatric neurosurgeons (5,9,11,16,24,25). However, recently, endoscopic techniques have become more prominent (3,5,7).

Endoscopy is a safe and effective treatment method in children (5,7,18,23). Patients with acute hydrocephalus caused by tumors are the best candidates for restoring CSF flow using endoscopic techniques. Additionally, cyst fenestrations to the ventricles or basal cisterns can be successfully performed using endoscopic techniques with low complication rates (5). Endoscopic third ventriculostomy (ETV) is a treatment option for patients with obstructive hydrocephalus. ETV has its own advantages and disadvantages similar to shunt systems (3,5,7,10). Today, shunting remains the first option for treating hydrocephalus in many countries. Meanwhile, shunt complications and dysfunctions are not uncommon, and shunt dependency is the main problem in children (9,11,13). However, ETV is proposed to overcome this problem (10).

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Recently, combined surgical techniques, such as ETV plus shunting or ETV plus aqueductoplasty, are proposed for a strong and aggressive treatment of hydrocephalus (6,18,21,23). In these methods, ETV is first performed. If ETV fails, a shunt system is inserted. Aqueductoplasty is performed as a treatment method in patients with aqueductal stenosis (6,21,22). Only one clinical series on the use of the combined methods has been reported in the literature (23).

Here we report our experience with pediatric hydrocephalus treated with three surgical approaches and compared our results with the relevant literature.

MATERIAL and METHODS

This retrospective study was approved by the Ethics Committee of Gulhane School of Medicine (Approval no: 2020/332). The study was conducted ethically according to the World Medical Association Declaration of Helsinki. Written informed consent was obtained from the parents of the patients for publication of data and images.

Sixty-one patients underwent endoscopic treatment for hydrocephalus in the Department of Neurosurgery between 2015 and 2020. Forty-six (75.4%) patients were children, and the data of these children were retrospectively reviewed. Patients who initially underwent shunt surgery were excluded. All patients had preoperative and postoperative computed tomography (CT) scans, whereas some patients underwent magnetic resonance imaging (MRI) to rule out any tumor formation. The demographic features, radiological findings, and associated malformations were recorded. The indication and type of surgery were determined based on the clinical and radiological findings of the children. ETV and aqueductoplasty were performed using endoscopic technique (Figures 1A-C; 2A, B). ETV plus aqueductoplasty was performed in children with enlarged fourth ventricle or aqueductal stenosis (Figure 2A, B). Shunts were inserted in case of ETV failure under endoscopic view (ETV plus shunt group).

All patients were followed up using clinical examinations and MRI scans periodically (Figures 3A-F, 4A-F, 5A-D). The ETV procedure was considered successful if the symptoms and signs of increased intracranial pressure were no longer evident and the dilated ventricle shrunk on postoperative MRI. Failure was defined as the persistence of symptoms and unchanged ventricular size after ETV (20).

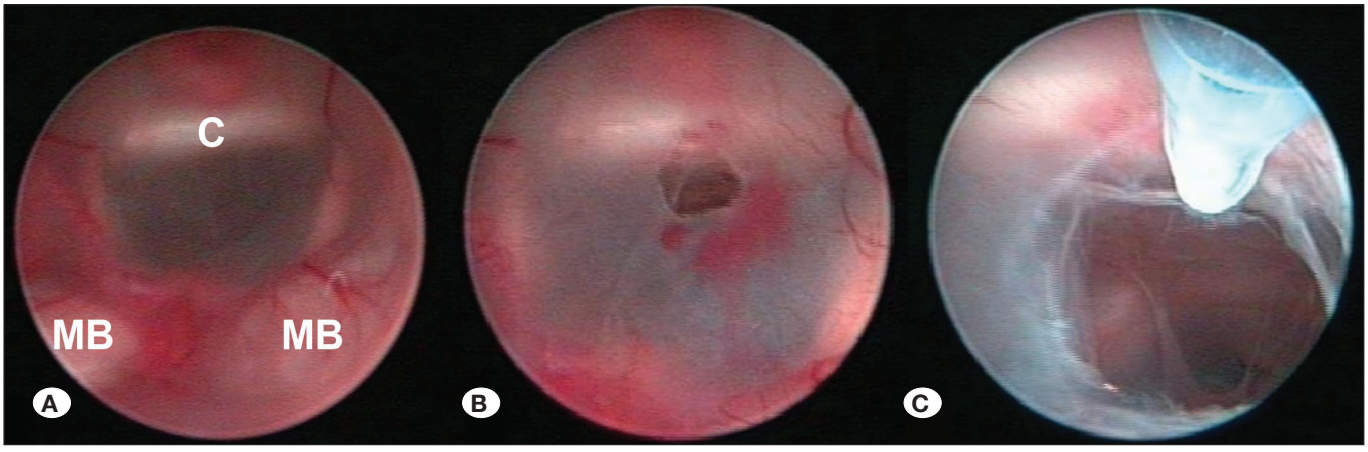

Figure 1: A) Endoscopic view of the floor of third ventricle (MB, mamillary body; C, clivus). **B)** Blunt perforation of the floor of the third ventricle and opening of the first hole using endoscope. **C)** Dilation of the stoma.

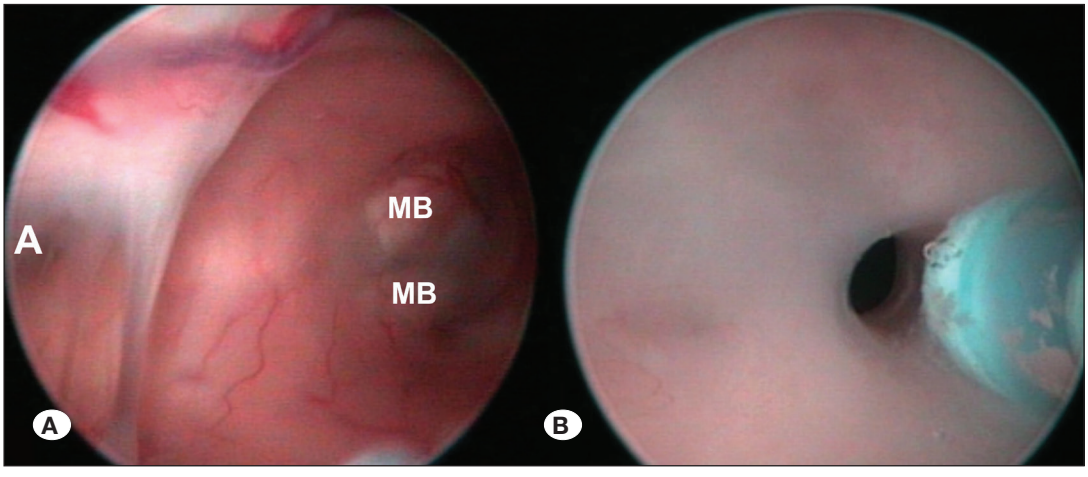

Figure 2: Endoscopic third ventriculostomy and aqueductoplasty in the same session. **A)** View of the floor of the third ventricle. (A, aqueduct; MB, mamillary body). **B)** Aqueductoplasty using a balloon catheter.

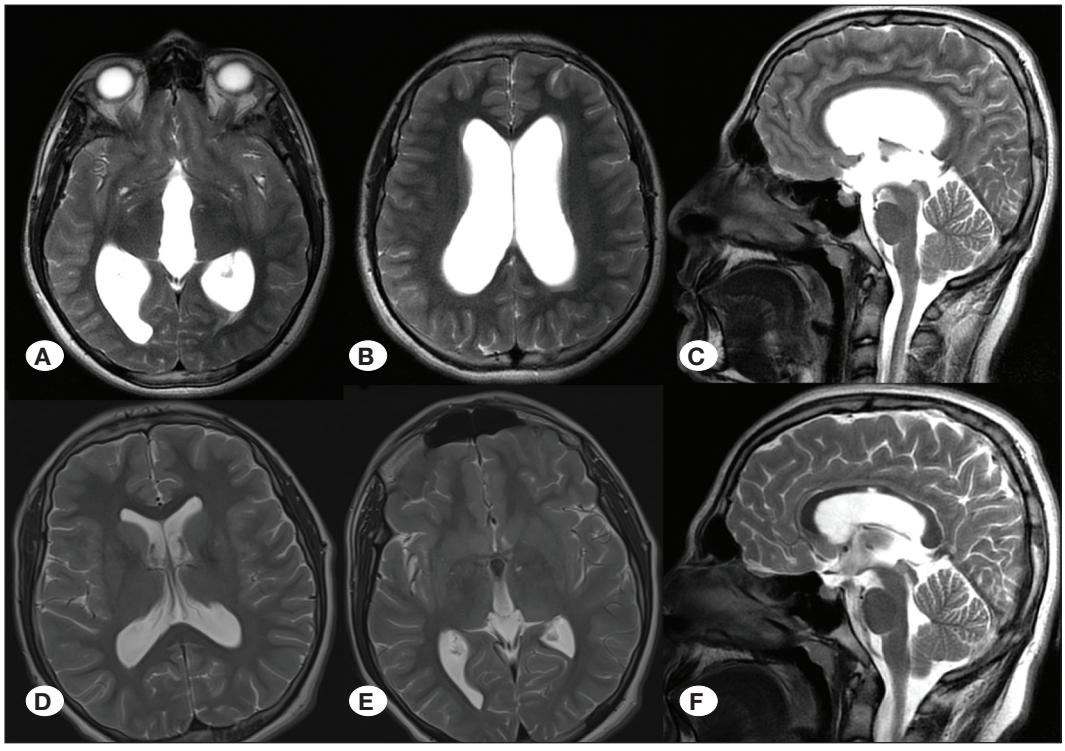

Figure 3: A 14-year-old male child with hydrocephalus. Preoperative axial **(A, B)** and sagittal **(C)** T2-weighted images show communicating hydrocephalus. The patient underwent endoscopic third ventriculostomy (ETV) alone and postoperative axial **(D,E)** and sagittal **(F)** magnetic resonance imaging scans confirm the efficacy of ETV 1 year after surgery.

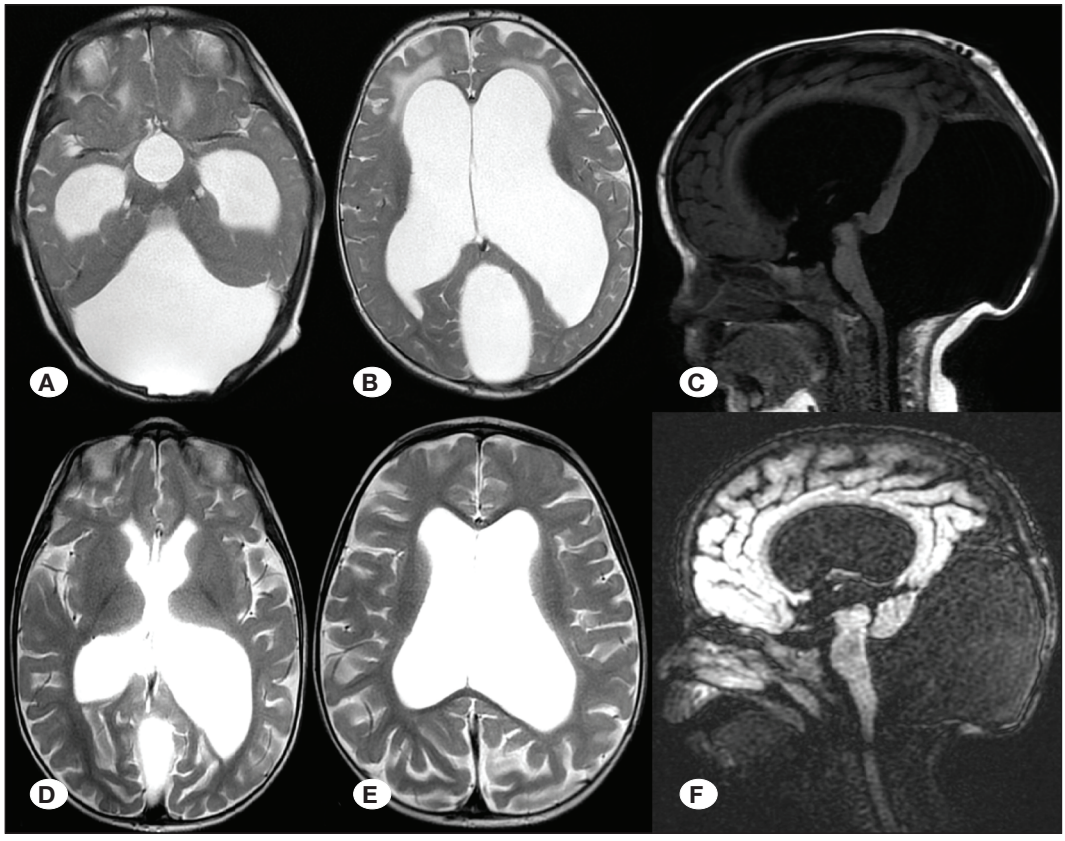

Figure 4: An 11-month-old female child with Dandy–Walker malformation and hydrocephalus. Preoperative axial T2-weighted **(A, B)** and sagittal T1-weighted **(C)** images show communicating hydrocephalus and cerebellar hypoplasia. The patient underwent endoscopic third ventriculostomy plus aqueductoplasty, and postoperative axial T2-weighted **(D, E)** and sagittal T1-weighted **(F)** magnetic resonance imaging scans confirm the decrease in ventricle size.

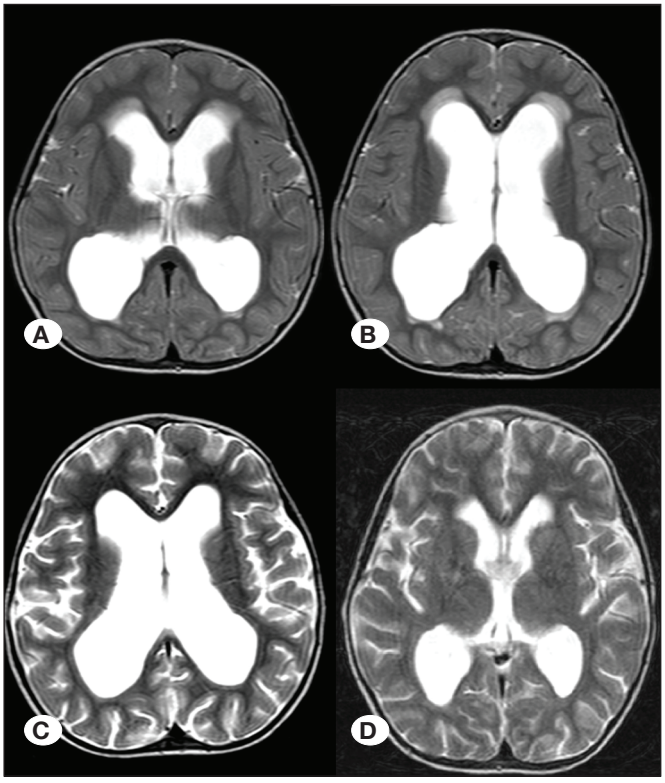

Figure 5: A 5-year-old female child with communicating hydrocephalus. Preoperative axial T2-weighted **(A,B)** magnetic resonance imaging scans show ventricular dilation, and postoperative axial T2-weighted images **(C,D)** reveal relatively small ventricles at the end of 6 months after surgery.

The mean follow-up period was 28 months, ranging between 6 and 60 months.

The relationship between the demographic features of the patients and the surgical technique was analyzed using t-test, and the relationship between the complications and type of surgery was analyzed using the Kruskal–Wallis test. P-values of less than 0.05 were used to denote statistical significance.

RESULTS

Among the 46 children, 24 (52.17%) were female, and 22 were male. The mean age of the patients was 25.33 months, ranging between 1 and 170 months. Moreover, 52.17% of the patients were younger than 12 months. Congenital hydrocephalus was present in 39 (84.78%) patients, whereas six patients had multicystic hydrocephalus, and one patient had a brain tumor. Hydrocephalus occurred after tumor removal. Endoscopic technique was used in all patients for treating hydrocephalus. ETV alone was performed in 21 (45.65%) patients. ETV plus ventriculoperitoneal shunting was performed in 19 (41.3%) patients. Simultaneous ETV plus aqueductoplasty was performed in six patients. No relationship was observed between patient age and the surgical technique applied. Additionally, no relationship was found between patient sex and the type of surgery (t-test, p=0.181; t=1.360).

No patient died perioperatively. Myelomeningocele was found in four patients, whereas encephalocele was observed in one patient (Table I). Postoperative complications were observed in 10 (21.74%) patients: eight had shunt dysfunction, one had subdural hematoma, and one had intraventricular hemorrhage. No relationship was observed between the surgical technique and complications (p=0.070). Five (10.87%) patients died during the follow-up period all of whom were female. Four of them were younger than 12 months, and one patient was 3 years old (36 months). Four patients underwent ETV plus shunting and one patient underwent ETV plus aqueductoplasty. No patients who underwent ETV alone died during the follow-up period.

DISCUSSION

Here we presented a series of pediatric hydrocephalus in 46 children over a 5-year period. ETV was performed as the first surgery in all cases; simultaneous aqueductoplasty was performed in six of the 46 patients. Ventriculoperitoneal shunting was performed in 19 children who previously underwent ETV, and shunt failure was detected in the follow-up period. The mortality rate was 10.87% all of whom were female and mostly younger than 12 months.

Hydrocephalus is an important health problem in children (14), and may be congenital or secondary to intracranial tumors or hemorrhages. Intracranial hemorrhage may trigger increased CSF secretion and then hydrocephalus (15). Hydrocephalus is usually associated with myelomeningocele in infants (19). Meanwhile, treating hydrocephalus is always challenging (24). Shunting is the most common and long-lasting treatment method for hydrocephalus. Different shunt systems had been proposed for diverting CSF, including ventriculoperitoneal, ventriculoatrial, ventriculopleural, and ventriculocisternal shunts (1,2,25). Nowadays, ventriculoperitoneal shunting is the most common treatment technique in children with hydrocephalus worldwide (9,12,13,16). However, CSF infections and shunt dependency are the main challenges for shunting (9,14). Close follow-up of patients with shunts is necessary, and quick brain MRI is the modality of choice in examining and following patients treated with shunts (12).

Shunts have many complications, such as obstruction, overdrainage, calcifications, and infections (1,9,12,14,16,24). Overdrainage can lead to subdural hematoma, craniosynostosis, and slit ventricle syndrome (8,9). Calcification may result in shunt fracture and rupture (16). However, the most fatal complication of shunting is infection, which may cause severe ventriculitis and even death (9,13,14). Meanwhile, some causes of death may be avoidable through early detection of symptoms (11,13,24). The diagnosis of shunt failure is sometimes difficult, and the clinical condition of the patients should be evaluated by serial radiological examinations (12,19,20,25). Therefore, many researchers seek new methods to overcome the risks of shunts. Antibiotic- or silver-impregnated catheters were developed for treating infected hydrocephalus (14). ETV was proposed as an alternative to shunts (3,5,10,25).

ETV is a popular treatment option, especially for obstructive hydrocephalus (5). In this technique, a stoma is created in

the floor of the third ventricle using an endoscope placed within the ventricular system through a burr hole (Figure 1A-C). This technique has become popular in the last three decades due to its ability to overcome shunt dependency in children (4). ETV provides a physiological restoration of CSF flow and is a shunt-free option for hydrocephalus in children (18). The success of ETV depends not only on the patency of ventriculostomy but also on the adequate resorptive capacity of arachnoid granulations. Moreover, the re-closure of stoma in ETV is its main drawback. Thus, a close follow-up is inevitable for either shunt surgery or ETV. Duru et al. have conducted a retrospective study on the efficacy of ETV in 51 children with obstructive hydrocephalus and emphasized that young age and etiology of hydrocephalus, such as spina bifida and aqueductal stenosis, are the main factors contributing to the potential failure of ETV (5). Additionally, they have highlighted that ETV is the method of choice even for patients with previous shunting. Possible causes of stoma closure in ETV include new arachnoid membranes, remnants of the second membrane inside the stoma, inadequate perforation, and CSF infection (5). Appelgren et al. have conducted a retrospective study involving 98 children with hydrocephalus and found treatment failure in more than 50% of the patients after ETV and ventriculoperitoneal shunting (1). Additionally, they have reported that prematurity and concomitant surgery are the major risk factors for shunt failure. In this study, all patients underwent ETV as the first surgery. Shunting was performed in 19 patients after ETV because of failure. However, we did not insert ventriculoperitoneal shunts in patients who underwent simultaneous ETV plus aqueductoplasty.

Aqueductoplasty is another treatment alternative for hydrocephalus, especially in children with aqueductal stenosis and isolated fourth ventricle (4,6,21,22). This technique is performed using an endoscope and balloon. Sometimes, a stent may be placed in the aqueduct (6). The main aim of this procedure is to enlarge the aqueduct to provide an effective CSF circulation between the third and fourth ventricles. Schroeder and Gaab have suggested endoscopic aqueductoplasty as an alternative to ETV for treating hydrocephalus caused by short aqueductal stenosis (22). Ersahin performed simultaneous ETV plus aqueductoplasty in 11 patients and reported that aqueductoplasty can be dangerous and useless in aqueductal stenosis, and simultaneous ETV plus aqueductoplasty is also useless (6). Da Silva et al. have emphasized that aqueductoplasty is an effective and successful treatment for membranous and short-segment stenosis of the sylvian aqueduct (4). In this study, we performed ETV + aqueductoplasty in six of the 46 patients, one of whom died in the follow-up period. This patient had multicystic hydrocephalus and myelomeningocele at birth and died secondary to meningitis.

Shim et al. have suggested simultaneous ETV plus ventriculoperitoneal shunting for infantile hydrocephalus. They have reported that the possibility of the synergistic advantage may exist, and one procedure can replace the other or can help each other (23). Navaei et al. have conducted a clinical study involving 49 infants and proposed ETV plus choroid plexus cauterization (CPC) with ventriculoperitoneal shunting in infants with obstructive hydrocephalus (17). They concluded that ETV/CPC is not inferior to ventriculoperitoneal shunting. In this study, we performed ETV plus shunting in 19 patients. None of them previously underwent shunting. We did not perform CPC in any patient.

The limitations of this study are its retrospective nature and small sample size.

Table I: Demographic and Clinical Characteristics of the Patients

Variable	n (%)
Sex	
Female	24 (52.17)
Male	22 (47.83)
Total	46 (100.0)
Age (months)	
<12	24 (52.17)
12-60	17 (36.96)
>61	5 (10.87)
Total	46 (100.0)
Treatment Method	
ETV alone	21 (45.65)
ETV+shunt	19 (41.31)
ETV+aqueductoplasty	6 (13.04)
Total	100 (100.0)
Associated Lesion/Malformation	
Myelomeningocele	4 (8.70)
Dandy-Walker Syndrome	2 (4.35)
Brain tumor	1 (2.17)
Encephalocele	1 (2.17)
Total	8 (17.39)
Survival	
Alive	41 (89.13)
Died	5 (10.87)
Total	46 (100.0)

CONCLUSION

ETV alone usually provides satisfactory clinical outcomes, whereas ETV plus shunting may be performed in case of ETV failure. It should be kept in mind that patients who underwent ETV plus shunting are more prone to death because of associated malformations. Larger series with long-term follow-up are needed to confirm the effectiveness of combined surgical approaches for treating pediatric hydrocephalus.

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AUTHORSHIP CONTRIBUTION

Study conception and design: MG,SG

Data collection: MG,AD

Analysis and interpretation of results: MG

Draft manuscript preparation: AD

Critical revision of the article: MG,AD

Other (study supervision, fundings, materials, etc...): AD

All authors (MG, SG, AD) reviewed the results and approved the final version of the manuscript.

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