Endoscopic third ventriculostomy in patients younger than 2 years: outcome analysis of 41 hydrocephalus cases

Clinical article

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Object. The object of this study was to analyze the outcome of endoscopic third ventriculostomy (ETV) in patients under 2 years of age and investigate factors related to ETV success or failure in this patient population.

Methods. The authors reviewed their experience in using endoscopic third ventriculostomy (ETV) in the treatment of 41 hydrocephalus patients younger than 2 years. The mean duration of follow-up was 45 months. The relationship between ETV efficacy and the following variables was analyzed: cause of hydrocephalus, level of CSF occlusion, primary versus secondary ETV, type of surgical procedure, head circumference, patient age at ETV, patient age at first manifestation of hydrocephalus, and anatomical features of the ventricle. Success of ETV was assessed based on the results of neurological examination and postoperative imaging during the follow-up period.

Results. The authors performed 32 primary ETVs and 10 secondary ETVs (ETV after hydrocephalus surgery) in 41 patients (a second ETV was performed in 1 patient). The success rates of primary and secondary ETV were 75.8 and 55.6%, respectively (no significant difference, p = 0.15). The ETV was clinically and radiologically successful in 30 (71.4%) of 42 procedures during a mean (± SD) follow-up period of 45.0 ± 4.8 months (range 12–127 months). A negative relationship was found between success of ETV and the thickness of the floor of the third ventricle (the most effective procedures were those in which the floor of the ventricle was thinnest [p < 0.05]). There was a highly significant correlation between ETV success and prolapse of the ventricle floor (p < 0.001). Also, there was an inverse relationship between ventricle floor thickness and the width of the third ventricle (p < 0.005). In our group of patients there was significant correlation between ETV success and patient age at onset of hydrocephalus (the most effective procedures were in patients in whom signs of hydrocephalus first occurred after 1 month of age [p = 0.02]).

Conclusions. Endoscopic third ventriculostomy was successful in 71.4% of procedures in children younger than 2 years and in 75.0% of procedures in infants. Success of ETV in children younger than 2 years depends not on the age of the patient or cause of hydrocephalus but on the thickness of the floor of the third ventricle and the patient’s age at first manifestation of hydrocephalus. (DOI: 10.3171/2009.11.PEDS09197)

Key Words • hydrocephalus • endoscopic third ventriculostomy • neuroendoscopy • child • infant • pediatric neurosurgery

Abbreviations used in this paper: CISS = constructive interference in steady state; ETV = endoscopic third ventriculostomy.
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83.3%, 48 with a mean of 47.8% in 19 publications; 2–4, 9–13, 18,20,21,23,27–30,33,42,46,48 the failure rate is significantly higher than in older children. We reviewed records related to 42 ETV procedures in 41 patients younger than 2 years, analyzing the relationship between ETV success and cause of hydrocephalus, a level of CSF occlusion, primary versus secondary ETV, type of surgical procedures, head circumference, patient age at ETV, patient age at the first manifestation of hydrocephalus, and anatomical features of the ventricle. The mean duration of follow-up was 45.0 months.

Methods

Between 1998 and 2009 we treated 112 patients with hydrocephalus by means of ETV. Of 112 cases, 47 procedures were performed in 46 patients under 2 years of age. Of these 46 patients, 41 (16 girls and 25 boys) had been followed up for at least 1 year and were included in our study. (The other 5 had follow-up of shorter duration and were therefore excluded.) The patient who underwent 2 ETVs was followed up for more than 1 year after the second one.

The mean patient age at the time of the ETV procedure was 0.88 ± 0.09 years (range 0.16–2.00 years). Of the 46 patients, 26 (63.4%) were younger than 1 year. The mean gestational age of the patients at the time of surgery was 36.67 ± 0.57 months (range 26–40 months). Seven patients (17.1%) had previously undergone shunt placement and were admitted to the clinic with shunt malfunction. The causes of shunt malfunction were obstruction of the proximal catheter in 5 patients and of the distal catheter in 2. An external drainage system had been placed in 2 patients, and 1 other patient had undergone removal of the shunt system 3 months before ETV due to ventriculitis. In one case (described below), the patient was admitted to our clinic 3 months after the initial ETV because of recurrent hydrocephalus and failure, and a second ETV was performed. The mean patient age at the appearance of the first signs of hydrocephalus was 1.95 ± 0.31 months (range 0.25–6 months).

In all cases, the immediate indication for ETV was progressive internal obstructive hydrocephalus. The specific causes of hydrocephalus in this patient group included aqueductal stenosis, occlusion of the Monro foramen, isolated ventricles, occlusion of the fourth ventricle, brain tumor, and multiple levels of intraventricular occlusion. In addition, some patients had a history of failed shunt revision, ventriculitis, or shunt infection.

Contraindications for ETV include the presence of severe comorbid conditions, inflammatory changes of the scalp, and anatomical features not conducive to endoscopic treatment (sharp narrowing or full occlusion of the interpeduncular cistern, narrow ventricles, and tumor of floor of the third ventricle). High levels of protein, leukocytes, or erythrocytes in the CSF and the presence of drainage systems or subdural hematomas did not constitute contraindications for ETV.

The hydrocephalus had developed as a result of bacterial meningitis in 14 patients, intraventricular or subarachnoid hemorrhage in 5, congenital aqueductal stenosis in 2, membranous occlusion of the aqueduct in 1, both bacterial meningitis and intraventricular or subarachnoid hemorrhage in 2, Chiari malformation Type II in 5, Dandy-Walker malformation in 10, and tumors of the posterior cranial fossa in 2. The occlusion was at the level of the aqueduct in 24 (58.5%) of 41 patients and at the level of the fourth ventricle in 18 (43.9%). The causes of hydrocephalus and occlusion were determined according to pregnancy and labor data, clinical findings, MR imaging (including CISS MR imaging), CT, shuntography, ventriculography, intraoperative findings, and the analysis of CSF.

At admission 37 patients had neurological signs of intracranial pressure such as vomiting, progressive macrocrania, divergence of cranial sutures, and the Parinaud sign. Four patients had no clinical signs of increased intracranial pressure, and the diagnosis was based on sonographic and MR imaging findings, which demonstrated a rapid increase in ventricle size. Five patients had papilledema. In addition to the medical and surgical history, clinical neurological data, the results of ophthalmological examination, craniotherapy, and the condition and the size of the fontanels were recorded for each patient.

All patients underwent sonography, CT, or MR imaging before ETV and during follow-up. In addition, in 36 patients, MR imaging with CISS was performed before ETV to determine the level of CSF occlusion, and in 2 patients MR imaging with quantitative analysis was performed, using oblique scans perpendicular to the axis of the stoma. The sizes of the ventricles, the size of the Monro foramina, the width of the third ventricle, the anatomy of the basal cisterns, the direction of the floor of the third ventricle, the level of CSF occlusion, periventricular edema, and subarachnoid space were estimated using the MR imaging studies. Patients with shunt systems in place underwent shuntography and/or ventriculography to identify the level of shunt occlusion.

All ETV procedures were performed with the aid of the Gaab neuroendoscopic system (Karl Storz GmbH) with patients in the supine position in a state of general anesthesia. Twelve of the ETVs were performed via the standard frontal precoronal bur-hole approach; in 30 ETVs (in children with large anterior fontanel), a lateral ventriculostomy approach was used (if necessary, bone rongeur was performed to provide a watertight dural closure after the endoscopic procedure). Then, we inserted an endoscope into the lateral ventricle, estimated the CSF transparency, and located the Monro foramen and the third ventricle floor. The usual reference point of perforation was the midpoint between the infundibular recess and the 2 mammillary bodies. If the floor of the third ventricle was transparent or semitransparent, the point of choice was the projection of the posterior edge of the sella onto the median line. Blunt perforation was performed using an electrode (without coagulation) or forceps. Widening of the perforation was achieved by inflating a 2 Fr Fogarty balloon catheter. Inspection of the interpeduncular cistern was then performed; in 5 procedures inspection confirmed free communication between the third ventricle and the interpeduncular and preoptic cisterns, but in 37 procedures no communication was discovered. In these 37 cases, we then performed dissection of the dense...
arachnoid membranes (diencephalic and mesencephalic leaves of the Liliequist membrane as well as the medial pontomesencephalic membrane). Also, in 36 procedures we used a simple intraoperative hydrostatic pressure test to assess the mobility of the floor of the third ventricle and confirm adequate CSF flow through ventriculostomy.14

In 36 procedures we used the Gaab I scope, a rigid endoscope with a 3-mm Hopkins scope providing a 0° angle of vision (with respect to the instrument) and 4-mm Hopkins scopes providing 30 and 70° angles of vision. In 6 cases, in which the diameter of the interventricular foramen was < 7 mm, we used a Gaab II miniature neuroscope (3.2-mm scope diameter, 0° angle of vision, outer sheath diameter 4 mm), and in another we used a neuro-fiberoptic scope (2.8-mm scope diameter, 0° angle of vision). The operating sheath was affixed using a standard endoscope holder (Karl Storz GmbH). Success of the endoscopic procedure was assessed based on results of neurological examinations (including evaluation of motor and speech development, head circumference, and the size of the anterior fontanel) and postoperative imaging (MR imaging, sonography) during the follow-up period. Treatment was considered successful if, after the procedure and during the entire follow-up period, stabilization (or appreciable improvement) of the patient’s condition was demonstrated by the absence of clinical, ophthalmological, radiological and MR imaging findings of intracranial hypertension, and also absence of necessity of any surgical hydrocephalus treatment. Preoperative and postoperative evaluations of CSF flow through the aqueduct and/or ventriculostomy were performed using MR images (T2-weighted turbo spin echo sequences with the following parameters: TR 4300 msec, TE 117 msec, 3-mm slice thickness).

The mean duration of follow-up was 45.0 ± 4.8 months (range 12–127 months).

Results

All the procedures were technically successful and were completed without intraoperative complications. There was no postoperative mortality or morbidity. We performed 32 primary ETVs (that is, in patients who had not undergone hydrocephalus surgery before ETV) and 10 secondary ETVs (that is, in patients who had undergone previous hydrocephalus surgery). The success rates of the primary and secondary ETVs were 75.8 and 55.6%, respectively (no significant difference, p = 0.15). In 29 procedures only ETV was performed; in 13 procedures ETV was performed together with shunt ligation (7 procedures), aqueductoplasty (2 procedures), biopsy of the intraventricular part of a posterior fossa tumor (1 procedure), biopsy of a hemispheric cyst (1 procedure), and evacuation of a purulent discharge associated with ventriculitis (1 procedure). A second ETV was performed in 1 patient. There were no aborted procedures. The success of the procedures is summarized in Table 1. Based on clinical and radiological assessment during a mean follow-up period of 45.0 ± 4.9 months (range 12–127 months), 30 (71.4%) of 42 ETV procedures were determined to be successful and 12 (28.6%) were unsuccessful. Failure of the ETV procedure became clinically or radiologically evident after a mean of 6 months (range 1–23 months). In 9 cases of ETV failure, ventriculoperitoneal shunt insertion was performed: in 1 case a second ETV was needed; in 1 case a lumbo-peritoneal shunt was inserted; and in 1 case parents refused the offered shunt placement, so conservative therapy was provided. All patients with congenital aqueductal stenosis (2 patients) or membrane occlusion of the aqueduct (1 patient) were successfully treated by ETV. There was a 50% ETV failure rate in the patients with a posterior fossa tumor or postmeningitic-posthemorrhagic hydrocephalus. Nine (60.0%) of 15 ETVs in patients with postmeningitic hydrocephalus were successful, as were 4 (80%) of 5 in patients suffering from myelomeningocele (Chiari malformation Type II) and posthemorrhagic obstructive hydrocephalus. Similarly, 8 (80%) of 10 procedures in patients with Dandy-Walker malformation were successful (Fig. 1). Figure 2 shows the relationship between ETV success and patient age. In our series of patients no significant difference was found with respect to age (the ETV success rate in infants [children younger than 12 months] was 75.0%). Success in children younger than 2 years did not depend on the level of occlusion (success rates: 69.9% for aqueduct level vs 73.7% for fourth ventricle level). There was, however, a significant correlation between ETV success and patient age at first signs of hydrocephalus, with surgery being more effective in patients who were older than 1 month when hydrocephalus first occurred (p = 0.02).

In our opinion, the floor of the third ventricle can be classified as thick, average, or thin based on its thickness or as transparent, translucent, or opaque according to visual characteristics. (In all ETVs, we used the same optics and light intensity during the procedure.) In our patient group the mean width of the third ventricle (based on preoperative MR images) was 14.8 ± 0.6 mm. We estimated that the floor of the third ventricle was opaque in 33.3% of procedures, semitransparent (visualization only of a dorsum sellae) in 45.2%, and transparent (visualization of a dorsum sellae, bifurcation of a basilary artery, posterior cerebral arteries) in 21.4%. The floor of the third ventricle was perceptibly rigid in 23.3% of cases. There

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No. of Procedures (%)</th>
<th>No. of Successful ETVs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>only ETV</td>
<td>29 (69.0)</td>
<td>23 (79.3)</td>
</tr>
<tr>
<td>ETV &amp; shunt ligation</td>
<td>7 (16.7)</td>
<td>4 (57.1)</td>
</tr>
<tr>
<td>ETV &amp; aqueductoplasty</td>
<td>2 (4.8)</td>
<td>1 (50.0)</td>
</tr>
<tr>
<td>2nd ETV</td>
<td>1 (2.4)</td>
<td>1 (100.0)</td>
</tr>
<tr>
<td>ETV &amp; evacuation of purulent discharge (ventriculitis)</td>
<td>1 (2.4)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>ETV &amp; biopsy of hemispheric cyst</td>
<td>1 (2.4)</td>
<td>1 (100.0)</td>
</tr>
<tr>
<td>ETV &amp; biopsy of intraventricular part of posterior fossa tumor</td>
<td>1 (2.4)</td>
<td>0 (0.0)</td>
</tr>
<tr>
<td>total</td>
<td>42 (100.0)</td>
<td>30 (71.4)</td>
</tr>
</tbody>
</table>

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was a statistically significant correlation between ETV success and thickness of the floor of the third ventricle (the most effective operations taking place when the floor was transparent, $p < 0.05$). There was a highly significant relationship between ETV success and prolapse of the floor of the third ventricle ($p < 0.001$). Also, there was an inverse relationship between the thickness of the floor and the width of the third ventricle ($p < 0.005$). In Fig. 3 we show the relationship between ETV success and preoperative head circumference. After successful ETVs the size of the ventricles was slightly reduced compared with the preoperative size.

### Illustrative Case

**History and Presentation.** This 3-month-old boy arrived at our clinic in grave condition with obstructive posthemorrhagic hydrocephalus and a supracerebellar arachnoid cyst of the quadrigeminal cistern causing aqueductal stenosis. The first signs of hydrocephalus had appeared when he was 1 month old. Medical management of the condition had been attempted for 2 months but had not been effective. Examination showed severe neurological signs and deficits. The patient had progressive macrocrania, vomiting, decrease of consciousness, hyperreflexia,
and cranial asymmetry. His anterior fontanel was enlarged (5 × 4 cm) and bulging.

**Imaging Studies.** Preoperative CT ventriculography and postoperative MR imaging are presented in Fig. 4.

**First Operation and Postoperative Course.** The infant underwent ETV on an urgent basis. After induction of general anesthesia and incision of the scalp, a parasagittal incision of the fontanel was performed. Ventricular puncture was performed with a thin brain needle. The CSF pressure was measured at up to 35 mm Hg. A rigid 0° endoscope was inserted into the ventricular system (Fig. 5) and the lateral ventricles were found to be dilated. The endoscope was passed through the Monro foramen to the floor of the third ventricle and blunt perforation of the floor was performed with an electrode. In addition, the Monro foramen was dilated with a 2 Fr Fogarty balloon catheter. The diencephalic leaf of the Liliequist

![Fig. 3. Relationship between success of ETV and preoperative head circumference. The y axis values represent ETV success rates. The x axis values represent centile (cent) with respect to head circumference. R² = size of reliability of approximation.](image-url)

![Fig. 4. Illustrative case. Imaging studies.](image-url)
membrane was identified (parallel to the floor of the third ventricle and 1 mm from it) and was perforated and dilated with the Fogarty balloon catheter. The endoscope was inserted through the hole into the interpeduncular cistern. The dense mesencephalic leaf of the Liliequist membrane was then visualized and dissected for complete communication with adjoining cisterns. The flow of CSF between the third ventricle cavity and the subarachnoid space was restored.

Rapid improvement was observed in the immediate postoperative period. For 2 months the condition of the child was good, with a decrease in macrocrania and significant improvement in findings on psychomotor testing as well as MR imaging. Three months after the operation, however, neurological signs of hydrocephalus reappeared.

**Second Operation and Postoperative Course.** We decided to perform a second ETV (Fig. 6). After induction of general anesthesia and incision of the scar tissue, a parasagittal incision was made in the fontanel. High CSF pressure (up to 45 mm Hg) was noted. The endoscope was passed through the Monro foramen to the floor of the third ventricle and the stoma was observed to be completely scarred. Some technical difficulties were encountered in reopening the stoma because of a clearly defined rigid scar and slight continual bleeding. Arachnoid membranes that had not existed at the primary ETV were visible in the interpeduncular cistern between the clivus and pons on both sides of the basilar artery. The membranes were perforated with some technical difficulty due to their rigidity and slight continual bleeding. They were also dissected. Flow of CSF between the third ventricle and the subarachnoid space was restored.

Rapid improvement was observed during the immediate postoperative period and was sustained through 13 months of follow-up. At the latest follow-up visit, the child's condition was good.
Discussion

Shunt placement, due to its effectiveness in the early postoperative period, has become a widespread method of treating both obstructive and nonobstructive hydrocephalus. However, the high frequency (20–80%) and seriousness of postoperative complications lead to a significant decrease in the quality of patients’ lives. Each of these complications requires at least 1 surgical procedure for its treatment and can cause significant morbidity and mortality. Treatment of this morbid condition remains an unsolved problem in neurosurgery.

The first to use neuroendoscopic guidance to perform a third ventriculostomy was Mixter, who used a ureteroscope to connect the third ventricle and the interpeduncular cistern via the opening in the floor of the third ventricle in 1923. After that first experiment, the idea of endoscopic guidance for third ventriculostomy was abandoned. With the evolution of technology and the improvement of optical systems on the one hand and growing awareness of the problems related to shunt insertion on the other, neuroendoscopy was reintroduced in the 1970s. The new era in endoscopic surgery, and, in particular, neuroendoscopy, started with the development of optical fiber transmission, a new generation of video cameras, special high-power sources of cold light, and small and high-quality optical systems as well as the endoscopic instruments that allow for a wide range of operative procedures without craniotomy. Implementation of neuroendoscopy has allowed surgical treatment to be performed under direct visualization in a manner that is safer than traditional hydrocephalus treatment. Endoscopic operations have become a popular choice for hydrocephalus treatment.

There have been several studies of the effectiveness of ETV in children under 2 years of age. Kadrian et al. reported a strong effect of patient age on outcome. They reported that the reliability of ETV in infants younger than 1 month was extremely low. The maximum observed reliability of ETV in this group was 3.5 years. The authors reported the percentages of patients “presumed to have a functioning ETV after 5 years” as follows: 41% in patients 1–6 months old at the time of surgery, 58% in patients 6–24
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months old, and more than 70% in patients older than 24 months. These results correspond to the data reported by other authors.26

However, Javadpour et al.20 reported an ETV success rate of 33% (continued patency during follow-up in 7 of 21 patients) and found that success depended on etiology rather than on patient age.

Baldauf et al.2 studied noncommunicating hydrocephalus and the success of ETV in children younger than 2 years. They showed an overall success rate of 43%, which seemed to be dependent on both age and etiology. The procedure seemed to be more successful for hydrocephalus due to idiopathic aqueductal stenosis than for hydrocephalus from other causes.

Analysis of the success and failure of ETV in infants in the Netherlands confirmed that ETV should be considered as an initial treatment that carries a low risk of morbidity in these infants. As the immune system rapidly matures, postponing shunt implantation for several months or even weeks would make ETV worthwhile. Moreover, the authors noted that a second ETV should always be considered before shunt placement in young patients with a failed ETV, as the probability of ETV success rapidly increases 4 months after birth.3

The largest study of ETV success in very young children was conducted in Uganda and involved 153 children younger than 1 year.48 The ETV success rate among these patients was 53%. The surgery success rates for patients with myelomeningocele and aqueductal obstruction were 40 and 70%, respectively.

An analysis of data supplied by 22 identified Canadian pediatric neurosurgeons from 9 centers about ETV cases during the period from January 1989 to December 2004 showed that age was the primary determinant of ETV outcome in pediatric patients and that failure rates are particularly high in neonates and young infants.3,4,8

Fritsch et al.,13 reporting a 39% ETV success rate, present ETV as an effective alternative for the treatment of obstructive hydrocephalus in infants younger than 1 year. The authors note that age does not present a contraindication for ETV or increase the perioperative risk. They conclude that the success of ETV is determined by the cause of hydrocephalus.

In our series of patients we performed ETV for the treatment of obstructive hydrocephalus involving occlusion at the level of the aqueduct or fourth ventricle. According to our data, the most effective application of ETV was observed in patients in whom the floor of the third ventricle was relatively thin. We postulate that the stoma closes more rapidly when the wall (the third ventricle floor) is thicker. Our findings are supported by those of Javadpour et al.,20 who reported that the tendency to form new membranes is higher in infants than in older patients. Analysis of our data has not revealed any statistically significant difference in outcome with respect to age within our patient group, although ETV was the most successful in patients aged 6–12 months. Our data confirm that the operation’s success depends more on the patient’s age at the first manifestation of hydrocephalus: the later the age at the first manifestation, the higher the ETV success rate.

We did not find any significant differences in ETV success with respect to the cause of the hydrocephalus, although in patients with congenital aqueductal stenosis, membrane occlusion of aqueduct, and Dandy-Walker malformation, ETV was more successful in this as in previous series (Fig. 1).42 Endoscopic treatment has not provided good long-term success (<60%) in patients with hydrocephalus related to a posterior fossa tumor or in patients with postmeningitic or both postmeningitic and posthemorrhagic hydrocephalus.

There are data showing that ETV is highly successful (a success rate of 100% in 13 patients) in infants born prematurely who have posthemorrhagic hydrocephalus and have previously undergone shunt placement.46 The lowest success rate in that series (23%) was in patients who had sustained both hemorrhage and infection.

Korean authors have reported simultaneous implantation of a ventriculoperitoneal shunt and ETV as the first choice of treatment for hydrocephalic patients younger than 1 year old (83.9% success rate).39 Maybe placement of the ventricular catheter in the preoptine cistern under endoscopic guidance reduces the risk of stoma closure and development of new arachnoid membranes.41 On the other hand, these combined procedures do not provide patients with shunt independence and or freedom from shunt complications. More effective may be the routine placement of a ventricular reservoir during ETV in patients at great risk of ETV failure (for subsequent emergency access to the ventricular system or diagnosis of ETV failure)1 or bilateral choroid plexus cauterization in combination with ETV in patients with a myelomeningocele or hydrocephalus that is not postinfectious in origin.47

According to Mohanty et al.,32 reclosure of the stoma because of gliosis and scarring has been observed in 6–15% of ETV failures. They reported ETV failure in 13 of 72 patients, with 8 of the 13 being infants. Repeated endoscopic surgery was performed in 7 infants. In 3 of these 7, the stoma was found to be closed and was reopened; in 4, the stoma was found to be open, necessitating insertion of a ventriculoperitoneal shunt. The high rate of reclosure in infants can be explained as follows: as CSF absorption is impeded,22,45 there is a greater tendency for the development of new arachnoid membranes in infants.20,27 and there is also growth of gliotic, ependymal, and scar tissue.16 In our own patient group, one infant with closure of the stoma because of gliosis and the development of new arachnoid membranes underwent a second ETV, with good results during the follow-up period.

The intraoperative complications related to endoscopic operations that have been described in the literature are mostly related to the use of endoscopy at the early stages of introduction of the procedure, and lethal outcomes are very rare.17,36,37 In our case series there were no intraoperative complications of endoscopic procedures. However, based on our experience, it is necessary to note that these procedures must be performed only by a surgical team with significant experience in neuroendoscopic operations.

Conclusions

Endoscopic third ventriculostomy offers an effective technique for the surgical treatment of hydrocephalus in...
children younger than 2 years and provides an effective alternative to ventriculoperitoneal shunt insertion. In our group of patients under 2 years of age, ETV was successful in 71.4% of procedures; in infants, 75.0% of ETV procedures were successful. Success of ETV in children younger than 2 years depends not on the age of the patient or cause of hydrocephalus but on the thickness of the floor of the third ventricle and the age at first manifestation of hydrocephalus. It is necessary to introduce these methods in neurosurgical centers where hydrocephalus treatment is widespread.

Disclosure
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: GZ Sufianova. Acquisition of data: AA Sufianov. Initial drafting of the article: IA Iakimov. Critically revising the article: GZ Sufianova. Reviewed final version of manuscript and approved it for submission: AA Sufianov. Study supervision: GZ Sufianova.

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