Turk Neurosurg, 2023

Original Investigation

DOI: 10.5137/1019-5149.JTN.41786-22.1

Received: 27.07.2022
Accepted: 31.08.2022

Published Online: 03.03.2023

Success Rate of Repeat Endoscopic Third Ventriculostomy Procedure According to the Ventriculostomy Orifice Closure Patterns: A Single Institutional Series of 74 Patients

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ABSTRACT

AIM: To analyze the success rates of repeat endoscopic third ventriculostomy (re-ETV) procedure according to ventriculostomy orifice closure types in patients who have undergone a second neuroendoscopic surgery for non-communicating hydrocephalus.

MATERIAL and METHODS: The study included 74 patients who underwent re-ETV procedure due to dysfunctional ventriculostomy orifice. Ventriculostomy closure patterns are classified into three types: Type-1 is defined as the complete closure of the orifice with non-transparent gliosis or scar tissue. Type-2 represents the closure or narrowing of the orifice by newly formed translucent membranes. Type-3 pattern is defined as the blockage of CSF flow due to newly formed reactive membranes in the basal cisterns, with an intact ventriculostomy orifice.

RESULTS: The frequency of the ventriculostomy closure patterns was found as follows. Type-1: 17 cases (22.97%); Type-2: 30 cases (40.54%); and Type-3: 27 cases (36.48%). The success rate of the re-ETV procedure according to closure types was 23.52% in Type-1 cases, 46.66% in Type-2 cases, and 37.03% in Type-3 cases. A significantly higher rate of Type-1 closure pattern was observed in the myelomeningocele associated hydrocephalus cases ($p<0.01$).

CONCLUSION: In cases where ETV failure occurs, an endoscopic exploration with reopening of the ventriculostomy orifice is a preferable treatment option. Therefore, identifying patients who may benefit from the re-ETV procedure is essential. Type-1 closure pattern was observed to have a higher frequency in cases where hydrocephalus was associated with myelomeningocele, and the success rate of re-ETV seems to be lower in those cases.

KEYWORDS: Closure, Endoscopic third ventriculostomy, Reoperation, Success rate

ABBREVIATIONS: CSF: Cerebrospinal fluid, **ETV:** Endoscopic third ventriculostomy, **re-ETV:** Repeat endoscopic third ventriculostomy, **MMC:** Myelomeningocele, **MRI:** Magnetic resonance imaging

INTRODUCTION

Hydrocephalus is a condition that requires a purely surgical treatment. The goal is to bring the pathological tension induced by the cerebrospinal fluid (CSF) to the optimum level, where the patient can perform his/her motor, sensory, and cognitive neurological functions again in a healthy way. The treatment options are ventriculoperitoneal shunt surgery and endoscopic third ventriculostomy (ETV). ETV is considered superior to shunt surgery in many ways as it offers a low risk of complications and a solution closer to physiological function; moreover, it eliminates synthetic implant-related complications. The series published in recent years have reported high success rates of ETV (4,9,10,14,22,29).

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Considering its mechanism, the patients suitable for ETV are those with hydrocephalus with a limited CSF passage from the ventricular system to the subarachnoid space but without pathology in CSF absorption from the subarachnoid space to the venous system (2,3,12,20). However, studies show that the success rates of ETV are influenced by several parameters, such as patient age, etiology, presence of complex hydrocephalus, insufficient CSF absorption capacity, and history of myelomeningocele (MMC) surgery (7,12,30,32). The reason for the medium- and long-term relapsed hydrocephalus symptoms following ETV, referred to as "ETV failure," is the closure of the ventriculostomy orifice or the formed membranes that will impair CSF flow (5,13,15). In case of an ETV failure, the two treatment options are shunt surgery or reopening the ventriculostomy orifice with endoscopic exploration (re-ETV).

Identifying patients who can benefit from re-ETV is essential. Also, more studies are required on the parameters affecting the outcome and the success rates of re-ETV. This study aimed to analyze the success rates of re-ETV according to the ventriculostomy orifice closure patterns observed during the operations of patients who underwent neuroendoscopic surgery for the second time.

MATERIAL and METHODS

In this study, the medical records and imaging of 683 hydrocephalus patients who underwent neuroendoscopic surgery between January 2001 and December 2020 in Kocaeli University Faculty of Medicine, Department of Neurosurgery, were retrospectively analyzed. Patients with a history of intraventricular hemorrhage, CSF infection, and previous shunt surgery and in whom an adequate opening in the basal cistern membranes was not achieved in the first ETV procedure were excluded from this study. Ventriculostomy orifice closure was confirmed by clinical signs and cine phase-contrast magnetic resonance imaging (MRI). A total of 74 patients who underwent re-ETV due to ventriculostomy orifice closure were included in the study.

The patients were evaluated by dividing them into three age groups: "0–24 months," "24 months–18 years," and "adults." The etiologies of hydrocephalus were as follows: "aqueductal stenosis," "MMC-associated hydrocephalus," "intracranial tumor-associated hydrocephalus," "Dandy–Walker malformation-associated hydrocephalus," and "other" (associated with achondroplasia and vein of Galen malformation). By examining the surgery videos of the patients, data were obtained regarding the presence of perioperative hemorrhage complications, adequate penetration of the basal cistern membranes, and presence of spontaneous venous pulsation from the orifice following ventriculostomy. Furthermore, the closure patterns of dysfunctional ventriculostomy orifices were examined in the second ETV surgery videos.

Wagner and Koch classified ventriculostomy orifice closure patterns into three main groups, considering the characteristics observed, such as the presence of gliosis or translucent membranes at the third ventricle floor and of newly formed reactive membranes in the basal cistern (28). In Type-1, an opaque and parenchymatous third ventricle floor develops due to complete closure of the ventriculostomy orifice with gliosis or scar tissue. In Type-2, the ventriculostomy orifice is narrowed or completely closed with the subsequent formation of translucent membranes. In Type-3, the ventriculostomy orifice is open, but the CSF flow is blocked due to newly formed reactive membranes in the basal cistern (Figure 1).

Statistical analyses of all data obtained in the study were conducted using the SPSS software version 26.0 (IBM Corp., Armonk, NY, USA). Pearson's chi-squared test was employed to determine whether there is a significant relationship between categorical variables. If the *P*-value was less than 0.05, the difference was considered statistically significant.

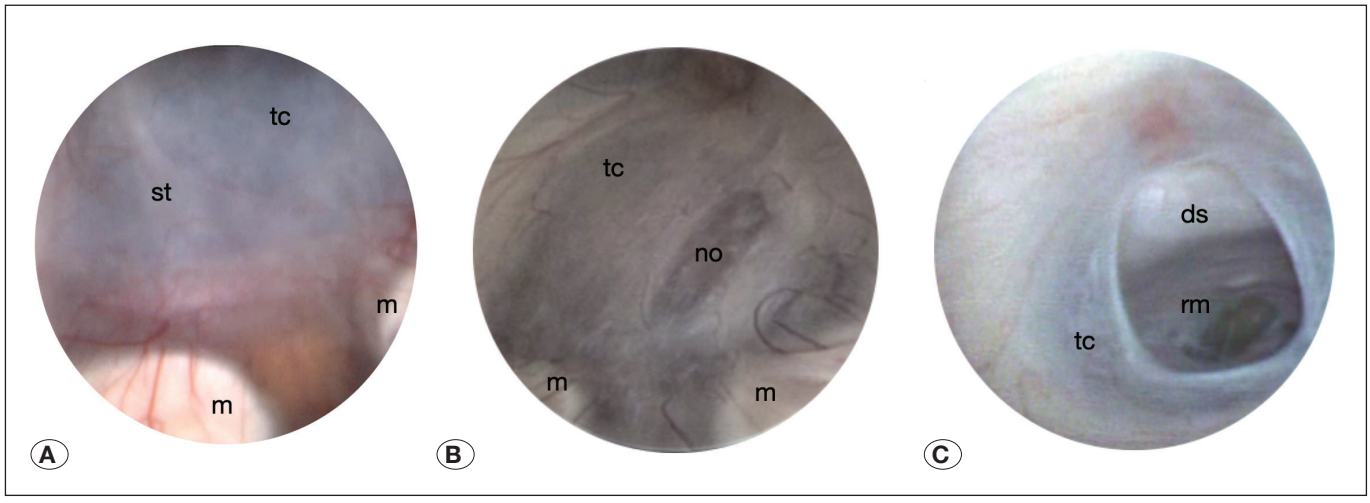

Figure 1: Types of ventriculostomy orifice closure observed in the second neuroendoscopic operation. Complete closure of the ventriculostomy orifice with scar tissue **(st)** is observed in Type 1 **(A)**. Narrowing of the orifice **(no)** by the translucent membrane in Type 2 **(B)**. Blocked cerebrospinal fluid flow due to the reactive membranes **(rm)** in the basal cistern while the orifice is intact in Type 3 **(C)**. Mamillary bodies **(m)**, tuber cinereum **(tc)**, and dorsum sellae **(dc)**.

RESULTS

Of the 74 patients included in the study, 34 were female (45.94%), and 40 were male (54.05%). The number of patients in the age group of 0–24 months was 37; 24 months–18 years, 19; and adults, 18. The mean age of the patients was 127.27 months (range, 2 months to 60 years). The etiologies of hydrocephalus were as follows: aqueductal stenosis in 35 cases (47.29%), intracranial tumor-associated hydrocephalus in 21 (28.37%), MMC-associated hydrocephalus in 14 (18.91%), Dandy–Walker malformation-associated hydrocephalus in 2 (2.70%), achondroplasia-related hydrocephalus in 1 (1.35%), and vein of Galen malformation-associated hydrocephalus in 1 (1.35%).

Ventriculostomy Orifice Closure Types

In terms of the ventriculostomy orifice closure types, Type-1 was observed in 17 cases (22.97%), Type-2 in 30 (40.54%), and Type-3 in 27 (36.48%). When the frequency of the ventriculostomy orifice closure types was evaluated according to age group, the following findings were obtained: In the "0–24 months" age group, Type-1 occurred in 12 cases (32.43%), Type-2 in 14 (37.83%), and Type-3 in 11 (%29.72). In the "24 months–18 years" age group, Type-1 was observed in three cases (15.78%), Type-2 in nine (47.36%), and Type-3 in seven (36.84%). In the adult age group, Type-1 occurred in two cases (11.11%), Type-2 in seven (38.88%), and Type-3 in nine (50%). When the age groups were compared, no statistically significant difference was found in the frequency rate of ventriculostomy orifice closure types observed.

The following findings were obtained when the frequency of ventriculostomy orifice closure types was evaluated according to the etiologies of hydrocephalus. Of the 35 cases of "aqueductal stenosis," Type-1 was observed in 3 (8.57%), Type-2 in 18 (51.42%), and Type-3 in 14 (40%). Of the 21 cases of "intracranial tumor-associated hydrocephalus," Type-1 was observed in 2 (9.52%), Type-2 in 10 (47.62%), and Type-3 in 9 (42.85%). Of the cases of "MMC-associated hydrocephalus," Type-1 was observed in 10 (71.42%), Type-2 in 1 (7.14%), and Type-3 in 3 (21.42%). Of the two cases of "Dandy–Walker malformation-associated hydrocephalus," Type-1 was observed in one and Type-2 in the other. Of the cases of "other," Types-1 and -2 occurred each in two cases. There were no statistically significant differences in frequency rates of "ventriculostomy orifice closure" between the cases of "aqueductal stenosis" and "intracranial tumor-associated hydrocephalus." However, the higher rate of the Type-1 closure pattern detected in the "MMC-associated hydrocephalus" group was statistically significant ($p<0.01$).

Surgical Treatment Success Rates of Re-ETV

Successful ETV was defined as an improvement in clinical findings after surgery and not needing surgical treatment during the follow-up period. In the 74 cases included in our study, the overall success rate of re-ETV was 37.83% (28 cases). The re-ETV success rate was 32.43% in the "0–24 months" age group and 47.36% in the "24 months–18" age group. In the adult age group, the success rate of re-ETV was 38.88%. Although a higher success rate was achieved in patients older than 2 years, it was not statistically significant. The re-ETV success rates were evaluated according to the ventriculostomy orifice closure patterns, and the following results were obtained. The success rate of re-ETV was 23.52% in cases with Type-1 closure pattern, 46.66% in Type-2, and 37.03% in Type-3 (Figure 2). These findings indicate that a relatively higher success rate was achieved in cases with Type-2 closure patterns and a lower success rate in Type-1. However, the compared variables were not statistically significant. When the re-ETV success rates in the etiological groups were evaluated, the following findings were obtained: a success rate of 40% in cases of "aqueductal stenosis," 38.09% in cases of "intracranial tumor-associated hydrocephalus," and 28.57% in cases of "MMC-associated hydrocephalus" (Figure 3). The difference between the success rates of re-ETV in different

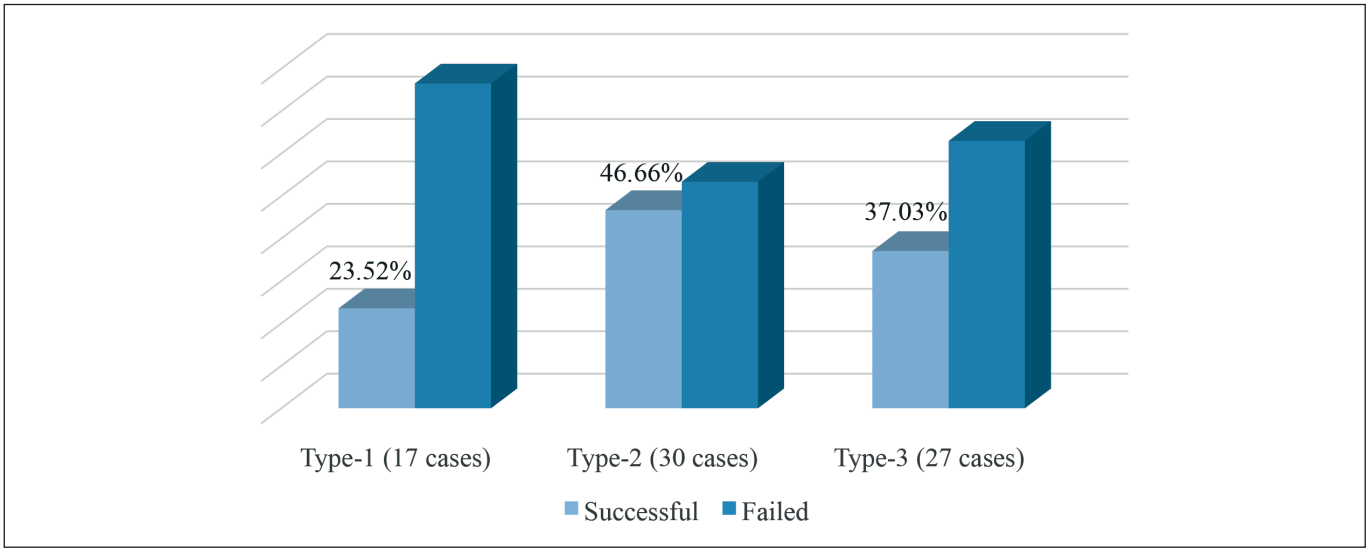

Figure 2: Repeat endoscopic third ventriculostomy success rates according to ventriculostomy orifice closure types.

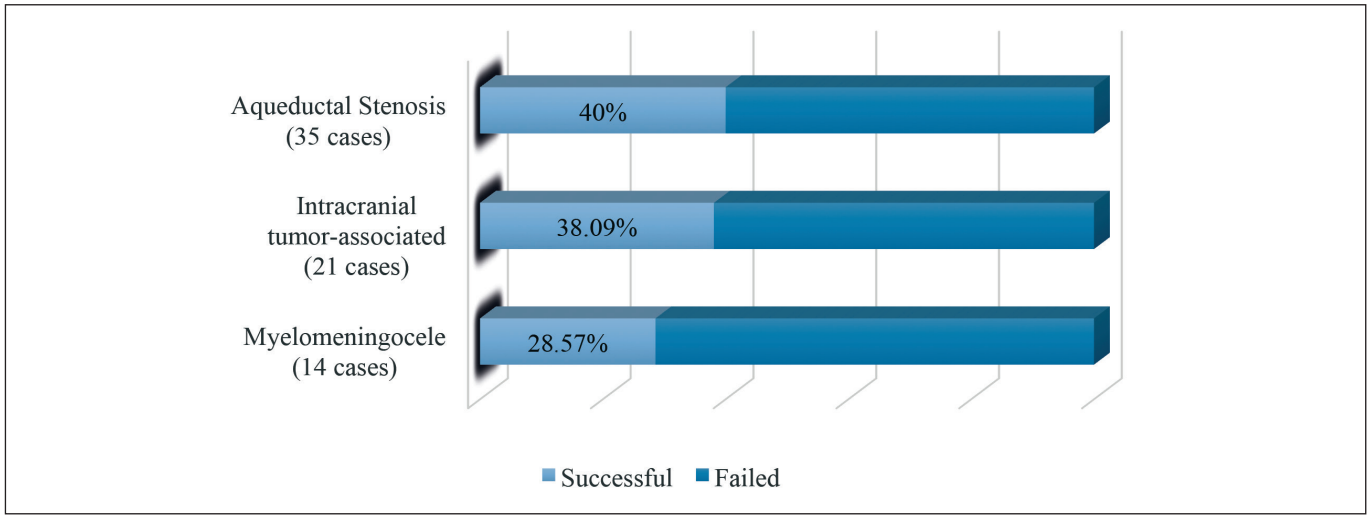

Figure 3: The success rates of repeat endoscopic third ventriculostomy in the etiological groups.

Table I: The Number of Patients with Successful and Failed Repeat Endoscopic Third Ventriculostomy Procedures in Etiologic Groups and Ventriculostomy Orifice Closure Types

	Type-1		Type-2		Type-3	
	Successful	**Failed**	**Successful**	**Failed**	**Successful**	**Failed**
Aqueductal Stenosis	0	3	8	10	6	8
Tumor-Related	1	1	4	6	3	6
Myelomeningocele	2	8	1	-	1	2
Dandy-Walker	-	1	1	-	-	-
Other	1	-	-	-	-	1

etiological groups was not statistically significant. Table I summarizes the success rates and number of failures in re-ETV patients classified according to the hydrocephalus etiologies and ventriculostomy orifice closure type.

DISCUSSION

At present, ETV is widely employed in the treatment of adult and pediatric obstructive hydrocephalus cases (2,3,9,12,27). This procedure has been reported to have a wide range of success rates, in which patient selection plays a significant role (9,15,18-21,24,27). While the success rate was reported to be 72%–75% in adult cases in the literature, it dropped to 25%–34% in pediatric cases (8,15,16,29,30). Previous studies, which included cases of MMC-associated hydrocephalus, reported an ETV success rate of 40% in infants and 64% in children older than 2 years (15,20,27).

Various mechanisms have been proposed to explain ETV failure in several studies. Wagner and Koch suggested that the most responsible factor is reclosure of the endoscopically established CSF flow pathway (28). Furthermore, some studies suggested that the presence of complicated hydrocephalus (a combination of communicating and obstructive hydrocephalus) can lead to ETV failure, and the difference in the CSF dynamics and brain viscoelasticity in infants may be the reason for the difference in the ETV success rates between adults and infants (3,31). In addition, history of failed shunt surgery, shunt infection, meningitis, and intraventricular hemorrhage have been reported as factors that negatively affect the success rate of ETV (17-19,25).

The anatomical characteristics of ventriculostomy dysfunction observed during secondary endoscopic exploration provide essential information on the possibility of successful re-ETV, and discussions on this subject are still ongoing (5,13,19,20,23,28). In this study, we aimed to discuss the success rates of re-ETV according to the ventriculostomy orifice closure patterns, regardless of known risk factors, only for parameters such as age and hydrocephalus etiologies in our 74 cases (75.67% pediatric patients, 24.33% adult patients). Thus, cases with risk factors for ETV failure, such as intraventricular hemorrhage, CSF infection, or a history of failed shunt surgery, were excluded. Evaluation of ventriculostomy with dynamic CSF flow MRI studies constitutes the primary diagnostic method in confirming ETV failure (1,6,26). Ventriculostomy orifice function, classified as “patent” or “no flow” in previous studies, was also included as a diagnostic criterion for ETV failure in this study (6,18).

The ventriculostomy orifice closure patterns observed in the cases during the second endoscopic exploration were determined based on the anatomical characteristics previously described by Wagner and Koch (28). The anatomical characteristics of dysfunctional ventriculostomy orifice were categorized into three groups, as in a study using the same classification (5): Type-1 is characterized by the presence of a parenchymatous and opaque third ventricle floor as a result of complete closure of the ventriculostomy orifice with gliosis or scar tissue; Type-2 is characterized by narrowing or complete closure of the orifice with formed transparent membranes; and Type-3 is characterized by blocked CSF flow due to the newly formed reactive basal cistern membranes. The frequency rates of ventriculostomy orifice closure patterns detected in this study were 22.97% for Type-1, 40.54% for Type-2, and 36.48% for Type-3. The most prominent and significant finding was that Type-1 had a high rate of 71.42% among cases of MMC-associated hydrocephalus. Furthermore, Type-1 was observed at a higher rate of 32.43% in patients younger than 24 months than in other age groups. In patients aged 24 months to 18 years, the rate of Type-1 was 15.78%, whereas in those aged over 18 years, it was 11.11%. These results indicate that Type-1 is responsible for ETV failure in approximately one-third of the patients younger than 24 months.

In previous studies, the success rates of re-ETV have been reported to range from 37% to 89% (5,17,18,21). In this study, which included 74 cases, the overall success rate of re-ETV is 37.83%. When the distribution analysis of the re-ETV success rates according to the ventriculostomy orifice closure types was conducted, the group with Type-1 closure pattern had a success rate of 23.52%; Type-2, 46.66%; and Type-3, 37.03%. Evaluation of these results revealed that in cases with Type-2 closure pattern, the chance of re-ETV success can be approximately twice those with Type-1. Because parameters such as age and etiologies need to be considered, the direct and significant effects of these three types on the success rate of re-ETV cannot be suggested. In this study, the success rates of re-ETV in pediatric cases older than 24 months (47.36%) and in cases with Type-2 closure pattern (46.66%) are higher than the overall success rate. Furthermore, the re-ETV success rate (40%) in the case group with a hydrocephalus etiology of aqueductal stenosis is higher than those in other etiological groups. Although the success rate of these subgroups seems to be higher, the difference was not statistically significant.

Previous studies on the re-ETV success rates according to the ventriculostomy orifice closure types are scarce and focused on the pediatric population (5,11,13,17-20,24). This study discusses the types of ventriculostomy orifice closure and the success rate of re-ETV in the general population. It should be considered that valuable data will be obtained in the neuroendoscopic surgical management of hydrocephalus by developing the results and findings of this study with more comprehensive future studies.

CONCLUSION

ETV is an effective option for the treatment of obstructive hydrocephalus in both pediatric and adult populations. In cases where ETV failure occurs, an endoscopic exploration with reopening of the ventriculostomy orifice is a preferable treatment option. Therefore, it is important to identify patients who can benefit from re-ETV. According to the data obtained from this study, Type 1 ventriculostomy orifice closure pattern had a significantly higher frequency rate among MMC-associated hydrocephalus cases, but the success rate of re-ETV was found to be lower in these patients. The data obtained in this study that investigated the re-ETV success rate in the general population according to the ventriculostomy orifice closure types may be helpful for further studies focusing on re-ETV preferability.

ACKNOWLEDGMENTS

The data used in this article are mainly based on the thesis study of the corresponding author. Preparation for publication of this article is partly supported by Turkish Neurosurgical Society.

AUTHORSHIP CONTRIBUTION

Study conception and design: HES, VE
Data collection: HES
Analysis and interpretation of results: HES, YA, VE
Draft manuscript preparation: HES
Critical revision of the article: VE
All authors (HES, YA, VE) reviewed the results and approved the final version of the manuscript.

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