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REVIEW ARTICLE

Comparison of treatment modalities regarding the entity of the trapped fourth ventricle: A 20-year retrospective analysis of our clinical experience

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ABSTRACT

Introduction: The entity of the trapped fourth ventricle represents a clinical challenge, as it is a rare entity associated with a wide spectrum of underlying pathologic conditions and the proposed treatment options are restricted and frequently associated with complications and unfavorable long-term outcome. The majority of the affected individuals report a medical history of previous ventriculo-peritoneal shunt infection, as well as a precipitating factor for the entrapment (central nervous system infection, intraventricular hemorrhage, trauma). They come to clinical attention due to symptomatology attributed to mass effect that is exerted by the ballooned fourth ventricle on the brainstem and cerebellum.

Materials and Methods: We present our results, extracted from data derived from our medical center 20 years surgical experience and relevant outcomes in 120 pediatric patients diagnosed and managed with entrapped fourth ventricle. They were treated either with fourth ventricle-peritoneal shunt insertion or with an endoscopic approach. The relative efficacy of both techniques was recorded one year and five years after the initial operation and the data underwent statistical analysis. All patients who failed the initial therapeutic option were managed again with the aforementioned techniques, and their long-term results were recorded.

Conclusions: We recorded that after one year of follow-up, there were no significant differences in outcome when these two techniques were compared. However, when the results of five-year follow-up were compared between two groups, there was superiority, regarding the functional outcome, of the procedure involving the insertion of a fourth ventricular-peritoneal shunt. The outcome of patients that underwent a salvage procedure of any type did not seem to be different after a one-year follow-up period, being unable to verify the superiority of one technique over the other. However, there seems to be a superiority of the shunt procedure over the endoscopic technique regarding the functional outcome of these patients, five years after their second operation. Nevertheless, these results are only indicative and our data are insufficient to establish a statistical level of significance, probably due to the restricted number of patients that were incorporated in our survey.

Introduction

The entity of TFV (trapped fourth ventricle) refers to a relatively rare secondary event which is intimately related to a previous CSF (cerebrospinal fluid) diversion procedure, in cases of individuals that are suffering from hydrocephalus. The most frequently seen conditions, referring to pediatric patients, that are predisposing to isolation of the 4th ventricle, are hemorrhage related to prematurity, ventriculitis and inflammation. It is widely accepted that the choroid plexus of the fourth ventricle constitutes a source of continuous CSF production. The combination of unobstructed CSF production within the cavity of the 4th ventricle, along with an increased impedance in its outflow results in an ongoing accumulation of CSF and dilatation of the fourth ventricle. The offending pathophysiologic mechanism is attributed to the inflammation of the ependymal lining of the ventricle which is a consequence of the underlying causative pathological process. The ultimate result of that pathological process could be the obstruction of the outlets of the fourth ventricle (foramina of Luschka and Magendie), which ultimately leads to the development of this type of obstructive hydrocephalus[1,2]. In the vast majority of cases, these patients already harbor a ventriculoperitoneal shunt due to a pre-existing hydrocephalus referring to the supratentorial ventricular compartment. The combination of obstruction of the fourth ventricular inlet (aqueduct of Sylvius) and outlets (foramina of Luschka and Magendie), along with a shunted supratentorial ventricular compartment is the prerequisite for the development of an isolated and dilated fourth ventricle[3]. This dilation may be responsible for the development of clinical and neurological signs and symptoms that are identical to those that could be attributed to a posterior fossa mass lesion. Namely, these patients come to clinical attention with cerebellar and brainstem compression symptoms[4], albeit they are harboring a functioning supratentorial ventriculoperitoneal shunt.

Multiple treatment options have been investigated in order to manage the entity of the TFV, and this fact mainly relates to the inability to establish a treatment option that is universally accepted as the most effective and appropriate for all patients. More precisely, our therapeutic armamentarium includes options ranging from a separate posterior fossa shunt, open decompression with fenestration, and endoscopic procedures[2]. Nevertheless, no single technique can qualify over others as the one that is most suitable for all patients, probably because of the divergence of the underlying offending pathology. Additionally, our inability to prove that a distinct technique is definitively superior over the other available options could be related with the lack of sufficient data in the literature. It seems that a detailed radiological evaluation, along with a surgical intervention that is planned based on the underlying pathologic entity, are prerequisites for the development of an effective and personalized treatment protocol.

To the best of our knowledge, a current review of the literature lacks any evidence that address a comparison, based on a long-term experience, between the most widely accepted treatment options. In the current study, we retrospectively analyze our results and present our relevant experience, centered on pediatric patients, along with long term outcomes. the treatment options that were offered at our institution were endoscopic aqueductal reconstruction procedures and separate shunt placements (independent from the already existing for the management of supratentorial hydrocephalus).

Aim and Scope

Our aim was to compare the relative efficacy of both of the aforementioned techniques in the long term. More precisely, we attempted to compare the long-term prognosis of patients that were diagnosed with TFV and were treated either endoscopically or via a separate shunt insertion. We tried to investigate if there is a better long-term outcome when one of these techniques were used in patients suffering from TFV. Moreover, we attempted a comparison of the long-term results regarding the use of both of these techniques as a salvage procedure, that is after these patients are seeking again medical attention after failure of their initially offered treatment option.

2. Methods

Patient Characteristics

In order to describe our study design, we would like to mention that this is a retrospective analysis of data that were collected from patients that were suffering from the entity of the entrapped fourth ventricle, regardless of its underlying etiology. All of our participants were surgically managed, either endoscopically or via the insertion of a separate fourth ventricle-peritoneal shunt. Additionally, we collected all relevant data that were referring to those patients who needed a reoperation because of failure of the initially

offered treatment option. These patients were divided into two groups, based on the type of the initial operation. After that, each group was divided into two subgroups with an equal number of participants and all patients of these new subgroups received the same salvage procedure. The long-term outcomes of these patients are collected and analyzed.

After giving consent by the Bioethics Committee of our Hospital (Pediatric Hospital of Athens, 'Agia Sophia'), a retrospective analysis of institutional data was conducted, referring to pediatric participants (0–16 years old) suffering from entrapment of the fourth ventricle, irrespective of its underground pathophysiology. All of our participants share in common that they were treated to our hospital due to isolation of the fourth ventricle between 1996 and 2016. The treatment modalities included the insertion of a separate ventriculoperitoneal shunt (all these patients were already suffering from hydrocephalus that was previously managed with a ventriculoperitoneal shunt insertion), as well as endoscopic aqueductoplasty.

A separate ventriculoperitoneal shunt system, with a central catheter that was inserted in the fourth ventricle, was performed in 69 patients, that is 58% of the total number of patients. This subgroup included 38 male patients and 31 female patients (that is, 55% of males and 45% of female patients respectively). At the same time, an endoscopic approach was performed on 51 patients, that is 42% of the total number of our patients. This group was constituted from 26 males (51% of the total of this subgroup), as well as from 25 females (49% of the total, respectively).

2.4. Statistical Analysis

Statistical Analysis

Qualitative variables were expressed as absolute and relative frequencies. For the comparison of proportions chi-square and Fisher's exact tests were used. All reported p values are two-tailed. Statistical significance was set at $p<0.05$ and analyses were conducted using Stata statistical software (version 13.0).

Results

Our study was centered on a population of 120 patients who were admitted for the first time to our department with the diagnosis of entrapment of the fourth ventricle between 1996-2016. Clinical follow-up was completed in 2021, that is five years after the admission of our last patient. Our group of patients included 64 males and 56 females, aged between 0-16 years at their initial clinical presentation. The relevant demographic characteristics of our patients are presented on table 1.

Table 1. Patient epidemiology.

Variable	No. of patients (%)
Gender	
Male	64
Female	56
Etiology of hydrocephalus	
Infantile posthemorrhagic hydrocephalus	45
Congenital-atretic	17
CNS trauma	16
Meningeal infection-ventriculitis	42
Patient age at primary shunt placement	
< 1 year	68
< 1 month	29
1–6 months	23
6-12 months	16
1-10 years	44
>10 years	8
Patient age at initial diagnosis of ITV	
< 1 year	5
1-5 years	25
5-10 years	52
>10 years	38

An important parameter that was taken into consideration in our survey, was related to the functional outcome of these interventions over time, as we compared their relative effectiveness (and, accordingly the necessity to perform a secondary operation during the observation period). We compared the relative results that were attributed to the different management options at one and five years after the initial operation and present the relevant data.

More precisely, in the subgroup of patients which was managed via the insertion of a ventriculo-peritoneal shunt (central catheter inserted into the 4th ventricle), we recorded those 53 patients (77% of the total number of patients included in this subgroup) were harboring a still functioning shunt and no further intervention was needed.

On the contrary, we also recorded the relevant data that were attributed to the subgroup of patients that were operated on via an endoscopic approach. Based on that data, we mentioned that 37 patients of that group (73% of the total number of this subgroup) were harboring a functional outcome one year after their initial operation.

We also evaluated our patients 5 years after the initial intervention and we recorded our data, regarding our first treatment option. When we evaluated patients who were treated with the insertion of a shunt system, we recorded that the shunt was functioning (thus, no revision was required), in 44 cases (64% of cases). On the contrary, when we evaluated the data extracted from the patients that were initially treated endoscopically, we recorded that only 18 patients did not require an additional intervention (only 35% of the endoscopically treated patients were managed adequately). As a result, we mention that the 'functionality' of the initially inserted shunt systems to the 4th ventricle after 5 years was reduced from 77% to 64%, that is a reduction in the range of 13% was recorded. On the other hand, the relevant reduction that was related with the endoscopic approaches was in the range of 38% (73% at 1 year, 35% at 5 years).

During the follow-up period, two separate group of patients were developed, based on the population of patients that failed their initial intervention (endoscopic or shunt insertion). More precisely, we analyzed the data that were attributed to the group of 14 patients that failed their initial endoscopic intervention after 1 year follow-up. We subdivided them into two separate groups with equal number of patients. Endoscopic treatment was again performed in one of these groups, whereas shunt insertion was selected as the treatment strategy for the other subgroup.

We recorded the results that was collected from both of these new subgroups, one year after the second operation. We recorded that the shunt system was functioning in 5 patients (total number of patients =7), which means that 71% of patients were successfully managed. On the contrary, the secondary endoscopic approach was successful only in a group of 2 patients (total number of patients =7, 28,5% success rate). We additionally recorded the data of the patients that was managed successfully one year after the second operation, at a time interval of five years thereafter. Of the total number of 5 patients that were managed with shunt placement as their secondary management option, 4 patients had functioning shunts 5 years after shunt placement. We also evaluated the functional outcome of the patients that were successfully managed one year after the second endoscopic approach. As already mentioned, this subgroup included only 2 patients, and after a follow-up period of 5 years, only 1 patient was successfully managed (50% success rate).

We have already stated that after 1 year follow-up, regarding patients who were initially managed via the insertion of a separate ventriculo-peritoneal shunt, we recorded a total number of 16 failures, requiring revision. This subgroup of patients was subdivided into two separate subgroups, with equal number of patients. They were differentiated as patients of each one of them were subjected to a different treatment strategy (revision of the shunt system or a de novo endoscopic treatment). In the subgroup of patients that revision of the shunt system was selected as the treatment option, we recorded that 6 out of 8 patients harbored a functioning shunt 1 year after shunt revision (success rate 75%). On the other hand, the relevant success rate in patients that were managed with a de novo endoscopic approach was 37,5% (3 out of 8 patients were harboring a functioning endoscopic treatment). After a 5-year follow-up from the second operation (shunt or endoscopic approach) in this subgroup of patients, we recorded our terminal results. We mentioned that 5 out of 6 patients that were managed with a revision of their shunt system were harboring a functioning shunt. On the other hand, only 1 out of 3 patients that were endoscopically treated were recorded as harboring a functioning endoscopic approach 5 years after this approach. An important parameter

that was taken into consideration in our survey, was related to the functional outcome of these interventions over time, as we compared their relative effectiveness (and, accordingly the necessity to perform a secondary operation during the observation period). We compared the relative results that were attributed to the different management options at one and five years after the initial operation and present the relevant data.

Analysis

After collection of the relevant data, we analyzed the results that were centered on the subgroup of patients which was managed via the insertion of a ventriculo-peritoneal shunt (central catheter inserted into the 4th ventricle). We recorded those 53 patients (77% of the total number of patients included in this subgroup) who were harboring a still functioning shunt and, because of that, no further intervention was needed.

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During the follow-up period, two separate group of patients were developed, based on the population of patients that failed their initial intervention (endoscopic or shunt insertion). More precisely, we analyzed the data that were attributed to the group of 14 patients that failed their initial endoscopic intervention after 1 year follow-up. We subdivided them into two separate groups with equal number of patients. Endoscopic treatment was again performed in one of these groups, whereas shunt insertion was selected as the treatment strategy for the other subgroup.

We recorded the results that was collected from both of these new subgroups, one year after the second operation. We recorded that the shunt system was functioning in 5 patients (total number of patients =7), which means that 71% of patients were successfully managed. On the contrary, the secondary endoscopic approach was successful only in a group of 2 patients (total number of patients =7, 28,5% success rate). We additionally recorded the data of the patients that was managed successfully one year after the second operation, at a time interval of five years thereafter. Of the total number of 5 patients that were managed with shunt placement as their secondary management option, 4 patients had functioning shunts 5 years after shunt placement. We also evaluated the functional outcome of the patients that were successfully managed one year after the second endoscopic approach. As already mentioned, this subgroup included only 2 patients, and after a follow-up period of 5 years, only 1 patient was successfully managed (50% success rate).

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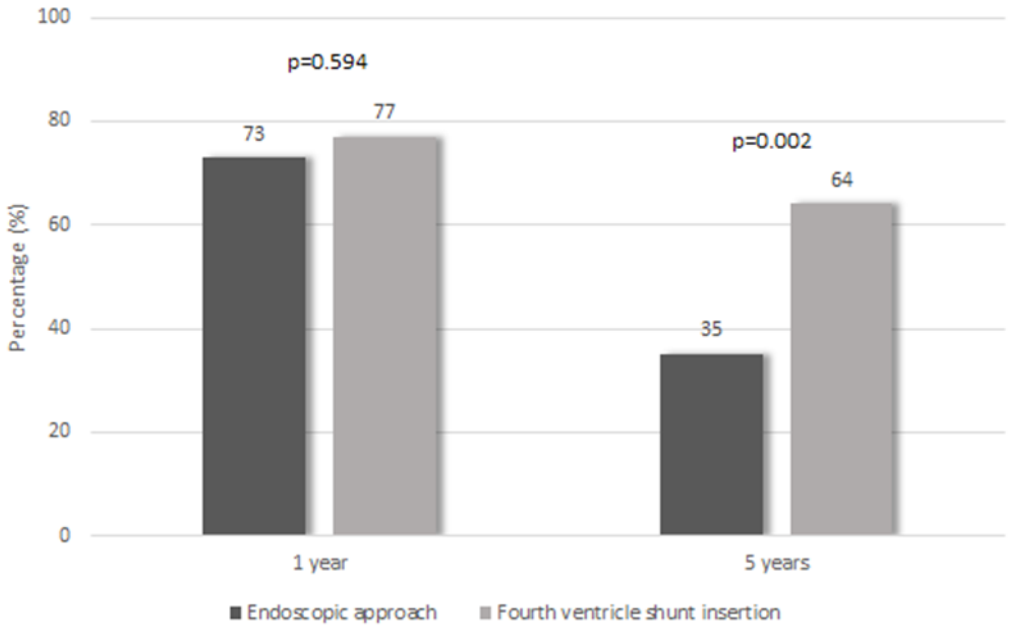
harboring a functioning endoscopic approach 5 years after this approach. We compared the relative outcomes of both groups of patients (treated via the insertion of a fourth-ventricular-peritoneal shunt and via an endoscopic approach) one year after the initial operation. We recorded that, regarding the subgroup of patients that were treated via shunt insertion, 53 out of 69 patients, that is 77% of them, harbor a functioning shunt. On the contrary, at the same time point, 37 out of 51 patients that were treated endoscopically (73% of them), remained well functioning, necessitating no salvage procedure. Our statistical analysis revealed that the relevant percentages that were indicating the effectiveness of both applied techniques (77% vs 73%) did not reveal any level of statistical significance (p=0,594).

Additionally, we collectively compared the data that were referring to the same subgroups of patients, 5 years after the initial operation. More precisely, our data revealed that at that time point 44 out of 69 patients that were initially treated via insertion of a central catheter in the fourth ventricle (that is, 64% of them), were still harboring a functioning shunt, necessitating no additional operation. On the other hand, only 18 patents out of 51, that is 35%, were recorded as not necessitating as requiring a revision of their initial endoscopic approach. Our statistical analysis verified that there was a significant level of statistical significance, as far as the relative long-term effectiveness of both treatment modalities was evaluated (p=0,002). Figure 1 depicts the relevant charts (on the left, there is a comparison between the two methods at one year after the initial operation, and on the right, the relevant data after a five-year time interval are evaluated).

Figure 1.



Our statistical analysis documented another conclusion, regarding the efficacy of the two aforementioned surgical approaches. It stated that the decline of the functionality of the fourth ventricle-peritoneal shunt systems after a five-year follow-up period (that is the percentage of patients requiring reoperation) was reduced from 77% to 64% (p=0,094), that is it was unable to be considered as statistically significant. On the contrary, the relative decline regarding the efficacy of the endoscopic approach was 37% (from 73% to 35%). This decline reached the level of statistical significance (p<0,001).

Figure 2 illustrates the relevant data regarding the shunt insertion, whereas figure 3 is based on the data that are referring to the endoscopic approaches.

Figure 2

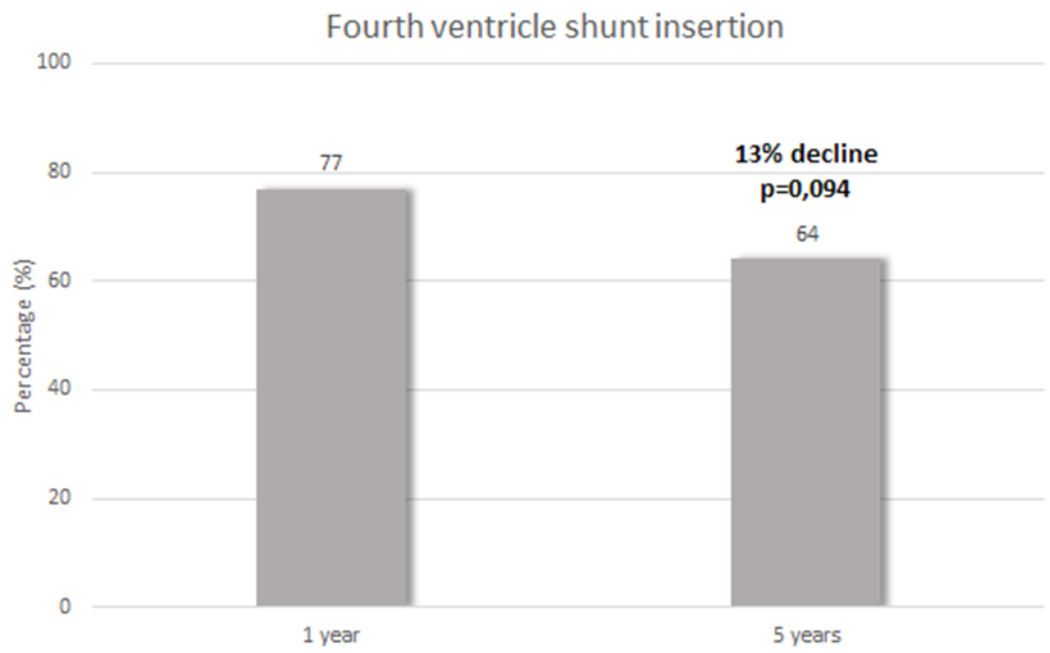
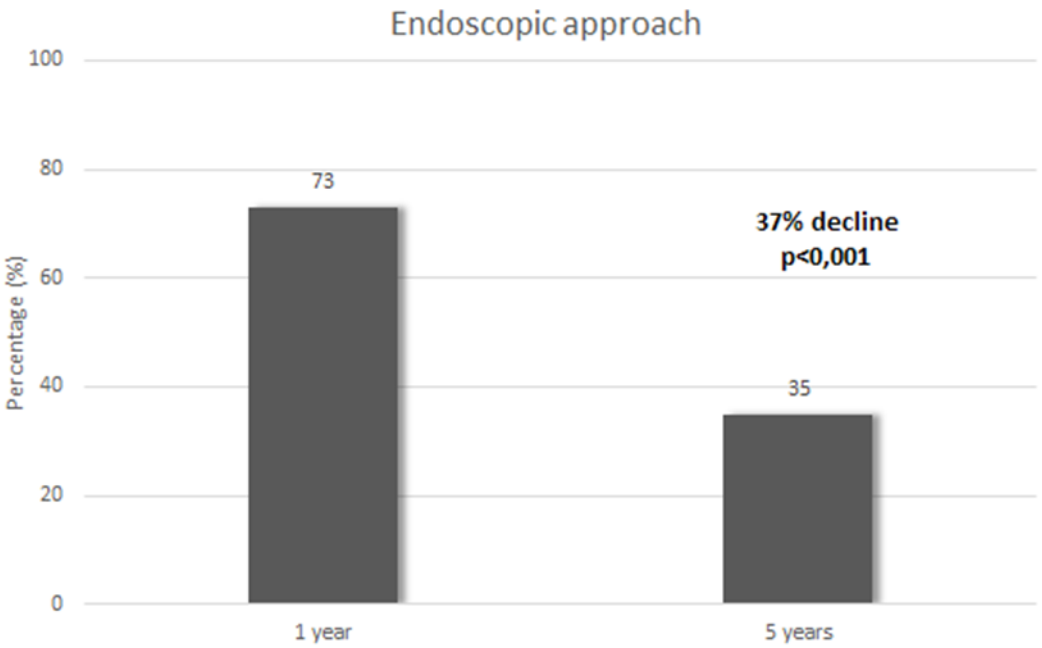


Figure 3



Our study also included the relevant data that were extracted from the subgroup of patients that were not functioning well after one year of the initial operation, irrespective of its nature (endoscopic approach or shunt insertion). We recorded those 14 patients that had undergone an endoscopic treatment and necessitated a reoperation after a one-year follow-up. They were blindly divided into two groups, consisting of equal number of patients, and a different treatment option was applied to each group (endoscopy vs shunt insertion). We collected the data of both groups, that were referring to our patients after a follow-up period of one year. We stated that 5 out of 7 patients (that is, 71%) treated via a shunt insertion as a salvage procedure, did not require an additional operation. On the contrary, only 2 out of 7 patients that were offered an endoscopic

approach as a salvage procedure were functionally well at that time point (relative efficacy 28,5%). Nevertheless, our statistical analysis was unable to verify an acceptable level of statistical significance, based on those results (p=0,286). We also collected the data referring to the patients of this subgroup, that were functionally well one year after the salvage procedure. We recognized that 4 out of 5 of these patients (that is, 80%) who were operated via a shunt insertion, did not need any additional operation at that time point. On the contrary, only one out of the two patients (that is 50%) that were offered an endoscopic treatment as a salvage procedure and were functioning well one year after their second operation, remained at a good clinical status in five years. We analyzed these data but no statistically significant difference could be composed (80% vs 50%, p>0.999).

On the other hand, we collected the relevant data referring to the subgroup of patients that harbored a failure of the fourth ventricular shunt, one year after its initial placement. They were also equally and blindly divided into two subgroups, each one of them received one type of treatment (endoscopy vs revision of the shunt system). After the first year from the second intervention, the insertion of fourth ventricular-peritoneal shunt is judged more successful again. More precisely, its functionality rises up to 75% (6 out of 8 patients), compared with that of the endoscopic approach, which is limited to 37,5% (3 out of 8 patients). Nevertheless, our analysis verified that no statistically significant difference could be established (p=0,315).

Five years after the second procedure, 5 out of 6 patients (that is 83,3%) who were harboring a functioning shunt one year after the salvage procedure did not necessitate any additional treatment. On the contrary, only 1 out of 3 patients (that is 33,3%) that were submitted to an endoscopic approach and were functionally independent at one year after the second operation, remained the same after a five-year follow-up period. Nevertheless, these results were unable to support the existence of a significant level of statistical difference (83,3% vs 33,3%, p=0,226). Figures 4 and 5 present, in a graphical matter, the relevant results.

Figure 4

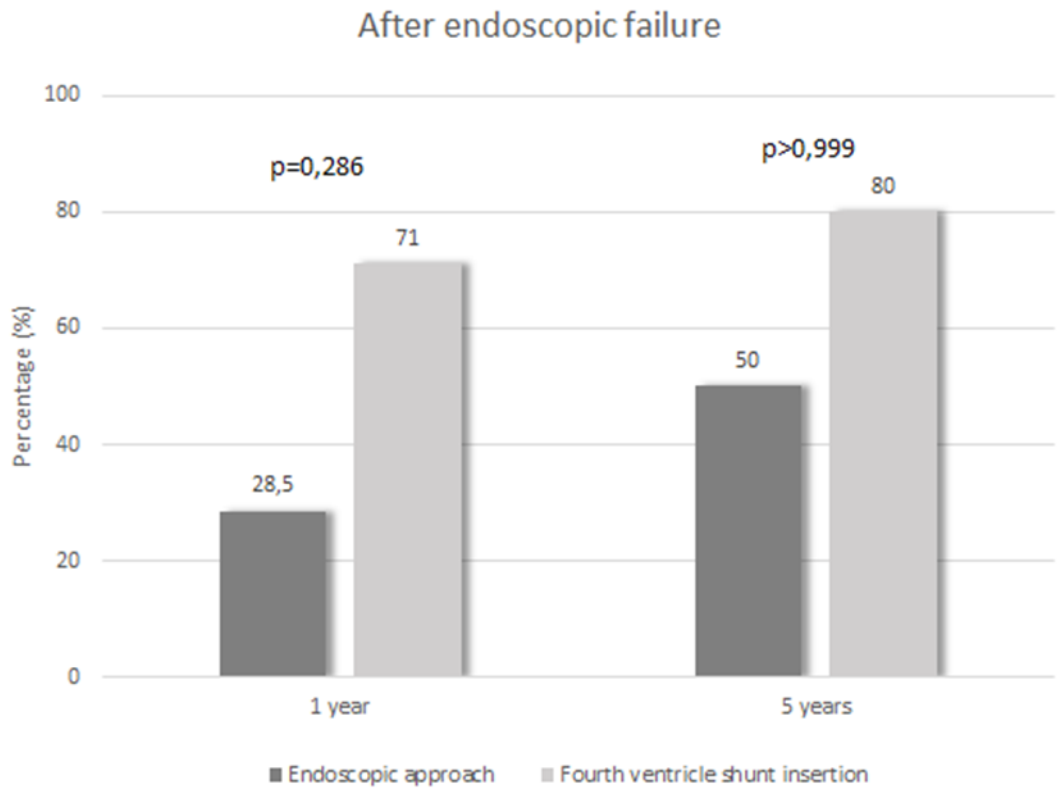
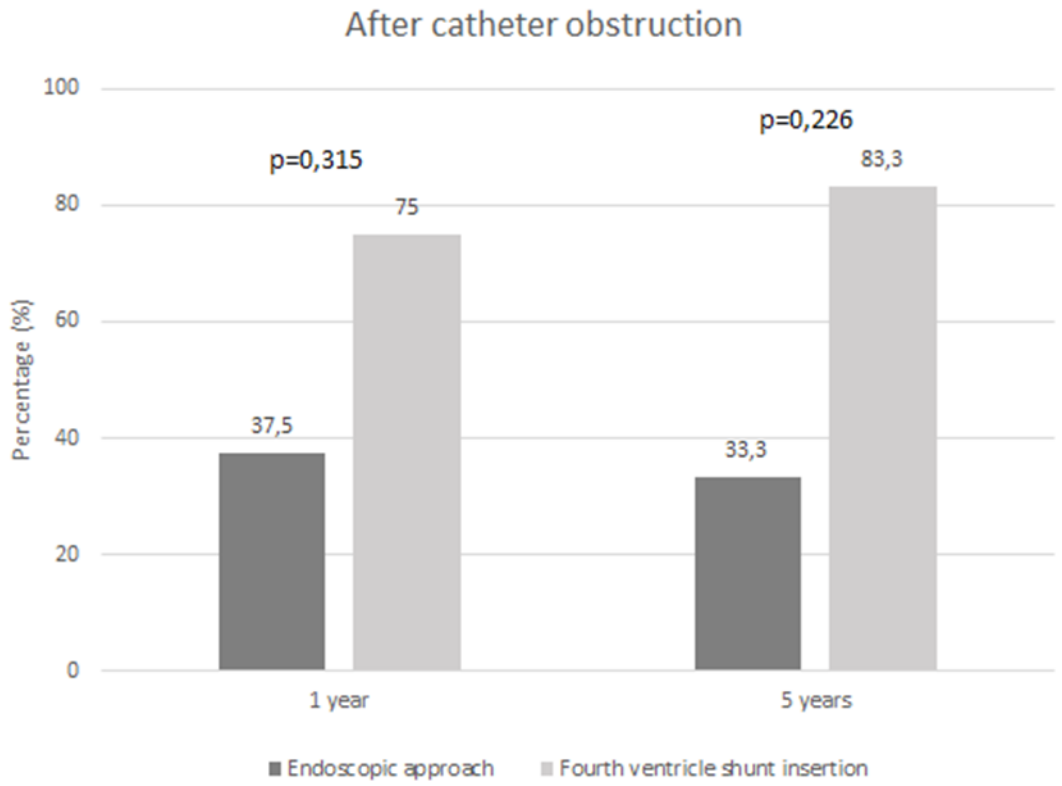


Figure 5



Discussion

The prerequisite for the development of the entity of the entrapped fourth ventricle is the development of obstruction of CSF flow, simultaneously located at the level of the aqueduct of Sylvius, as well as at the outlets of the fourth ventricle, namely the foramina of Magendie and Luschka. As an immediate consequence, a progressive dilatation of the fourth ventricle ensues, which secondarily compresses and displaces posteriorly the cerebellum. As a result of this situation, pressure arises on the entity of the brainstem, which subsequently results in its anterior displacement. Accordingly, a common occurrence is the development of upward herniation of the ballooned fourth ventricle through the tentorial hiatus, into the supratentorial compartment.

The entity of TFV is encountered in the majority of cases in a clinical setting which is delineated by the presence of a medical history in a child with posthemorrhagic or post infective hydrocephalus. The initial clinical presentation may be consistent with dilation of the entire ventricular system, although occlusion of the outlet foramina of the 4th ventricle is established. When these children come to clinical attention with signs and symptoms that should be attributed to the dilation of the 4th ventricle, they usually harbor a well-functioning supratentorial VP shunt, because of which the lateral and third ventricles appear to be within normal limits regarding their size and not responsible for the clinical and neurological situation. TFV is a pathological condition which may be combined with a wide variety of clinical and neurological signs and symptoms, with routine follow-up neuroimaging often been unable to detect essential imaging differentiation. More precisely, these patients may be clinically asymptomatic and not come to clinical attention, in which cases TFV remains an individual imaging finding. On the other hand, it may be associated with overt neurological signs and clinical features, which include truncal instability, poor feeding, dysconjugate eye movements, or somnolence. Unfortunately, the associated developmental delay in this group of children lets the clinical symptoms go undetected.

In accordance with the wide spectrum of associated pathophysiologic mechanisms that are implicated in the development of this syndrome, as well as because of the fact that this entity does not always come to clinical attention, there are no well-established and widely accepted indications

regarding the management of the IFV (isolated fourth ventricle). According to our literature review, there is a general agreement that surgical management should be reserved only for this subgroup of patients that are symptomatic[3,4,5,6,7]. Taking this evidence into consideration, the most widely accepted management strategy incorporates the concept that the IFV should be surgically treated only when the fourth ventricle remains persistently dilated, accompanied with neurological and imaging evidence of significant brain stem compression. Another clinical scenario that favors surgical intervention is consistent with the demonstration of a progressive dilatation-enlargement of the 4th ventricle during the regular follow-up of such patients.

When the available surgical options for IFV are considered, they could be broadly classified into the following subcategories: suboccipital craniectomy and outlet fenestration, fourth ventricular shunting procedures, and endoscopic procedures. Suboccipital craniectomy and fenestration of the outlet membrane have been selected as the most appropriate approach in patients suffering from posterior fossa cysts[3,5]. Nevertheless, this procedure failed to be widely accepted and, according to the literature, it has often been reserved for complicated patients with IFV, as a salvage procedure in cases that other approaches have failed[2,5,8].

The insertion of a central catheter into the cavity of the fourth ventricle, combined with a ventriculo-peritoneal shunt system, has historically proven to be the most widely adopted surgical option[2,5,9,10,11]. The central (fourth ventricular) catheter could be inserted either by a lateral trans-cerebellar route or by a midline transforaminal route. The transcerebellar route is generally regarded as more conventional, and is based on the insertion of the central catheter via a paramedian (lateral suboccipital) burr hole, with a trajectory perpendicular to the fourth ventricular floor (in other words, parallel to the clivus), following a lateral to medial direction[12]. Although injuries to the domes of the floor of the fourth ventricle during insertion of the shunt catheter have been reported, we did not mention such complications to our patients. Malfunctions have been reported with this technique[10,11] have been reported in the literature and this is also evident to a small minority of our patients. Another option is the insertion of the central catheter through a midline transforaminal approach, adopting a catheter trajectory that is parallel to the brain stem, paralleling its long axis avoids both these concerns[13]. We have rarely used this technique as we consider that is more technically demanding, as it requires intraoperative repositioning (from prone to supine) of the patient and we did not mention that it reduces the incidence of intra-operative complications.

As far as the endoscopic interventions are considered, they could be broadly divided into supratentorial and infratentorial approaches. The supratentorial approaches include the conventional trans-third ventricle- transaqueduct approach and trans-atrial approach. The most widely performed approach is based on the transfrontal-trans-third ventricular route, which necessitates the existence of an associated ventriculomegaly as a pre-requisite for safe navigation and visualization of the aqueduct, in order to perform the aqueductoplasty. After that, a stent is inserted in order to establish a communication between the supra- and infra-tentorial ventricular compartments. In our case series, a trans-aqueduct approach was selected as the optimum endoscopic approach. The most serious complication that is inherently related with aqueductoplasty and stenting is traumatic injury to the domes of the upper brainstem, which ultimately result in diplopia, ptosis and oculomotor paresis. We have encountered these complications in a small group of our patients but these complications were transient in the vast majority of patients and they disappeared after a period of several weeks to months.

Our statistical analysis compared the relative efficacy of both applicable surgical alternatives, based on recordings after one year and five years of follow-up, respectively. We concluded that there was no statistically significant difference after a one-year follow-up period, on the functional outcome of both groups of patients (endoscopically treated versus those that were submitted to insertion of a fourth ventricular-peritoneal shunt). Nevertheless, when the relative data concerning the outcome of these patients after a five years follow-up period were collected, it appeared that a statistically significant difference was evident between the compared subset of patients. More precisely, it seems that the subgroup of patients who were operated on via a shunt placement were more likely to need no further intervention, when they were compared with the endoscopically treated subgroup.

We expanded our investigation in order to investigate the relative efficacy of both techniques, when they were used as a salvage procedure, that is for patients who reported an adverse outcome

after the initial treatment option. We concluded that the relative efficacy of both techniques was comparable after one year and five years follow-up as no statistically significant difference was documented. Nevertheless, we could suppose that there was a superiority of the technique that involved a fourth ventricular shunt insertion, regarding the functionality of the intervention but the restricted number of participants was an obstacle to demonstrate any statistical significance. At this point, we would like to state that level of statistical significance of our results that were centered on the patients that underwent a salvage procedure is not so strong. This is intimately related to the restricted number of patients that participated to our survey. Further studies which could incorporate data that are derived from multiple reference centers would significantly enhance the statistical significance of our preliminary results and would potentially reveal more conclusions that were unable to be extracted from our search.

At this point, we would like to state that our study has several limitations. The major weakness of our case series is that it is based on a retrospective analysis of data that are collected from our patients. Apart from that, the selection of the type of surgical approach for each individual patient was based mainly on technical aspects. For example, in patients with functioning ventricular shunts and small ventricles, we considered that endoscopic approaches were difficult to be adopted and the option of a shunt was offered. Additionally, due to the relatively small patient population, we were not able to compare the relative efficacy of both of these techniques in terms of underlying pathologic substrate. This means that the relatively smaller success rate of the endoscopic techniques may be associated, at least in part, with the fact that the selection criteria of the patients were more related with technical aspects and not the offending pathology that was accompanying the TFV.

Conclusions

Our study supports the concept that the entity of TFV constitutes a condition that is rare but is difficult to manage. We strongly believe that both the insertion of a fourth ventricle-peritoneal shunt and the relevant endoscopic approaches are both effective and relatively safe treatment options, regarding the management of TFV. We would like to underline the fact that most of these patients have already been shunted, with a ventriculo-peritoneal shunt inserted in the supratentorial ventricular compartment. Undoubtedly, a wide variety of treatment options have been reported in literature, and all of them are accompanied with varying outcomes. Based on the results of our series, we strongly consider that an insertion of a central catheter in the 4th ventricle, combined with a separate shunt system, constitutes a technically simple, safe, effective, albeit a less physiological option for TFV.

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