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ORIGINAL PAPER

Success of pure neuroendoscopic technique in the treatment of Sylvian arachnoid cysts in children

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Abstract
Introduction Neuroendoscopic approaches to Sylvian arachnoid cysts (SACs) constitute an alternative treatment option to craniotomy for fenestration and shunting procedures. In this study, the authors discuss their experience on pure neuroendoscopic technique in the treatment of SACs in children.
Results The results of treatment of 20 children (range of age, between 7 months and 17 years) with Galassi type II (*n*, 5) or III (*n*, 15) SACs who were subjected to pure neuroendoscopic fenestration procedure were presented. It was possible to perform the cystocisternostomy endoscopically in all children with several stomies. The site of the opening was between the optic nerve and the carotid artery in 19, between the carotid artery and the oculomotor nerve in 17, and below the oculomotor nerve in 7. The stomies were enlarged in all cases using the double balloon. Three of the cases required repetition of the operation and two cases required "cystoperitoneal shunt" implantation. There was one minor complication in a patient who had an asymptomatic postoperative subdural effusion, which resolved spontaneously. Of the 18 cases, in which the neuroendoscopic procedures succeeded, 10 showed a reduction in cyst size. The mean follow-up period was 53 months.
Discussion Our results suggest that "pure neuroendoscopic" approach can be used safely in the management of SACs in children. We recommend at least two fenestration sites for an effective marsupialization of the cyst within the basal cisterns. In pediatric cases, the use of a small diameter rigid endoscope allows to reach safely the planned target areas.

Keywords Arachnoid cyst · Children · Endoscopy · Sylvian · Technique

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Introduction

Congenital arachnoid cysts are collections of cerebrospinal fluid located entirely within the arachnoid matter and are thought to arise from abnormal splitting or duplication of the arachnoid membrane during development [1, 17, 19]. These cysts are a relatively common pathology accounting for up to 0.75–1% of nontraumatic intracranial mass lesions as reported in autopsy and neuroradiological studies [20]. They can develop anywhere within the subarachnoid space in relation with the arachnoid cisterns; however, the most frequently encountered site in both adults and children is the Sylvian fissure [7, 18].

Sylvian arachnoid cysts (SACs), commonly denominated temporal cysts or middle fossa arachnoid cysts, are particularly challenging for the pediatric neurosurgeons. Although the majority of these lesions are asymptomatic, they may develop into a range of signs and symptoms which frequently include headache, macrocrania, temporal bone bulging, increased intracranial pressure, epileptic seizures, hydrocephalus, and psychomotor retardation in children [12, 20].

The indication for surgical treatment of SACs is a matter of debate. The rationality of preemptive treatment in children, or the necessity of surgical indication in patients with "common" symptoms like headache, is still being discussed [6, 22]. The optimal method of treatment for SAC also remains controversial. Neuroendoscopic approaches to SACs constitute an alternative treatment option to craniotomy for fenestration and shunting procedures.

Current debate on the treatment options for SACs seems to concern whether these cysts should be approached endoscopically rather than by craniotomy and microsurgical manipulation. Both techniques are suggested to assure similar rates of successes, failures, and complications [6]. However, there is growing number of studies about the use of neuroendoscopic approach in the treatment of SACs [4, 8–11, 13, 15, 20]. In this study, the authors from two centers combine their 10 years data on the pure neuroendoscopic fenestration technique in the treatment of SAC in children and discuss the effectivity of this technique.

Material and methods

Patients

The data of 20 patients, who were treated for SACs by pure neuroendoscopic fenestration techniques in two different centers between February 2000 to August 2010, were retrospectively analyzed. There were 7 female and 13 male patients. The age of the patients ranged from 7 months to 17 years. The data about the clinical presentation, preoperative cyst size and classification, endoscopic fenestration sites, clinical evolution, postoperative cyst size at the most recent neuroradiological investigation, and video recordings of the procedures were reviewed. The neuroendoscopic procedure has been performed only for symptomatic large SACs (Galassi II and III). Surgery was indicated in children under 2 years of age with evolutive macrocrania with important shift and compression of the adjacent brain parenchyma at MRI and/or temporal bossing on bone CT scan. In the series, 5 patients had Galassi type II cysts (25%) and 15 had Galassi type III cysts (75%). Eleven cysts were located in the right side, 7 cysts were located in the left side, and cysts were bilateral in 2 cases. The most frequent clinical signs and symptoms were headache in 10 children, seizures in 10, macrocrania in 6, hemiparesia in 6, and temporal bulging in 6 children. None of the children had been operated on for their cyst before.

Surgery

In all the patients, pure neuroendoscopic fenestration has been performed without any additional procedures. To approach the Sylvian cysts, laterally located burr holes have been used. Burr holes have been made on the coronal suture and 5–6 cm lateral to the midline or just below the Sylvian fissure. Endoscopic fenestrations have been made by using 0° rigid rod-lens neuroendoscopes (outer diameter of 4.0 mm or 3.5×2.5 mm by Karl Storz GmbH & Co., Tuttlingen, Germany) using free-hand technique. All operative procedures have been recorded by video imaging systems. The landmarks for the orientation were the free edge of the tentorium, the Sylvian fissure with the arterial trunks, and cranial nerves. Communication between the cyst and basal cistern (cystocisternostomy) has been made either through the space between the optic nerve and internal carotid artery (ICA) or through the space between the third cranial nerve and ICA or through the space between the third cranial nerve and the tentorial edge or by creating a combination of these (Fig. 1). The site has been decided on the basis of the aspect of the deep membrane (thickness and transparency). Several holes within the deep membranes have been performed using the blunt tip of the monopolar probe and forceps (ventriculostomy forceps from Storz®, Tuttlingen, Germany) and/or scissors. Care has been taken to open all layers (Fig. 2). The stomia has been also enlarged using the double balloon catheter (neuro-balloon catheter from Integra Neurosciences®, Antipolis, France) (Fig. 3). The major factor influencing the site and number of openings was the thickness of the membranes. In almost all cases, several membranes were present and had to be successively opened to ensure a good

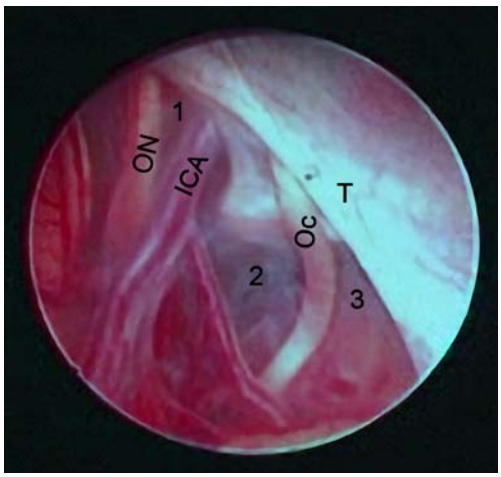

Fig. 1 Intraoperative endoscopic view of a right-sided Galassi III Sylvian arachnoid cyst case. The landmarks for the orientation are: optic nerve (*ON*), internal carotid artery (*ICA*), oculomotor nerve (*Oc*), and the free edge of the tentorium (*T*). In the pure endoscopic fenestration technique, communication between the cyst and basal cistern (cystocisternostomy) can be made either through the space between the optic nerve and internal carotid artery (*1*) or through the space between the oculomotor nerve and internal carotid artery (*2*) or through the space between the oculomotor nerve and the tentorial edge (*3*) or by creating combination of these

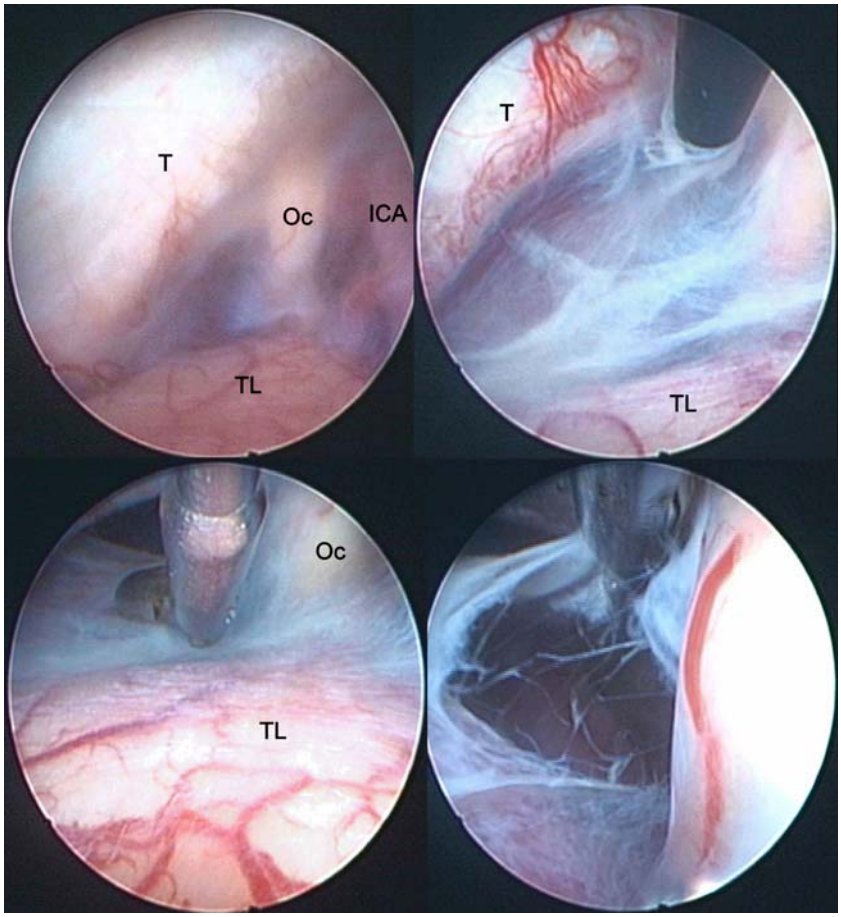

Fig. 2 Intraoperative endoscopic views of a left-sided Galassi II Sylvian arachnoid cyst case. The landmarks for the orientation are: tentorium (*T*), oculomotor nerve (*Oc*), internal carotid artery (*ICA*), and temporal lobe (*TL*). The site for perforation is decided on the basis of the aspect of the deep membranes (thickness and transparency). First the membranes between the oculomotor nerve and the tentorial edge are perforated using the blunt tip of the monopolar probe (*upper right*). The hole within the deep membranes is enlarged by using the ventriculostomy forceps and scissors. Care is taken to open all layers to ensure a good in- and outflow

in- and outflow. Perforation through a single site has been performed in 3 of the 20 children (the space between the optic nerve and ICA in two cases and the space between the third cranial nerve and the tentorial edge in one case). In 11 of the 20 children, cystocisternostomy has been performed by creating two stomies (one between the optic nerve and ICA and the other between the third cranial nerve and ICA). In 6 of the 20 children, cystocisternostomy has been performed by perforating all three spaces. An early postoperative head, CT scan has been performed in all cases. The surveillance is based on clinical examination and control cranial MRI examinations. The flow of cerebrospinal fluid (CSF) through the cystocisternostomies was confirmed by signal voids around ICA or tentorial edge on early postoperative T2-weighted coronal MR imaging studies in all available cases. Postoperative resolution of the symptoms related to increased intracranial pressure and/or improvement in neurological symptoms due to compression of the adjacent brain parenchyma were accepted as the main success criteria for the procedure. Postoperative control MRI studies were usually scheduled two times a year, the earliest being at the third month following the surgery in succeeding cases. In case of the recurrence of symptoms, MRI studies were performed on admission. Treatment failure was defined as the need of cystoperitoneal shunt surgery for the persistence or the recurrence of symptoms. Characteristics of the 20 cases and their surgical data are summarized in Table 1.

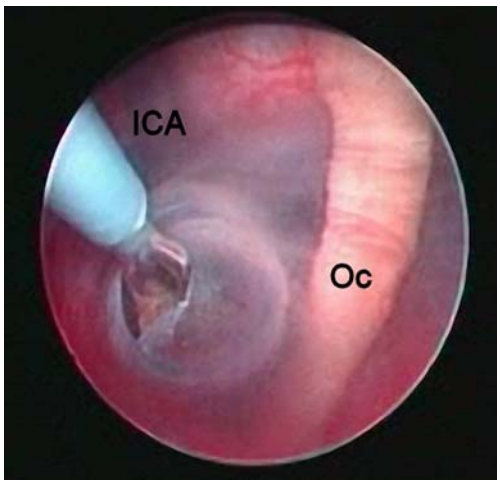

Fig. 3 Intraoperative endoscopic view of a right-sided Galassi III Sylvian arachnoid cyst case. Balloon catheter is being inflated to dilate the fenestration orifice between the oculomotor nerve (*Oc*) and internal carotid artery (*ICA*)

Table 1 Patient characteristics and the data including endoscopic fenestration sites, results and outcome are summarized in the table

Case No	Age	Sex	Galassi type and side	Symptoms sign	Fenestration type	Postoperative complication	Follow-up (months)	Radiologic outcome	Clinic outcome
1	8 years	F	III, R	Seizures, headache	1+2	−	12	CR	Headache relieved; no seizures with reduction in antiepileptic drug dose
2	10 years	M	III, R	Left hemiparesia, headache	1+2	−	51	CU	Mild improvement in hemiparesia; headache relieved
3	17 years	M	III, L	Seizures, headache	3	−	114	CU	Symptoms recurred; CP-Shunt implanted
4	5 years	M	III, L	Right hemiparesia, seizures	1	−	94	CR	Reduction in seizure frequency and moderate improvement in hemiparesia after repeat endoscopic fenestration (1+2+3)
5	7 months	F	III, R+L	Macrocrania	1+2	−	27	CR	Normalized skull growth rate
6	17 months	M	III, R+L	Macrocrania	1+2	−	37	CR	Normalized skull growth rate
7	16 years	M	III, R	Seizures, headache	1	−	69	CU	No improvement even after repeat endoscopic fenestration (1+2); CP-Shunt implanted
8	5 years	M	II, L	Temporal bulging, seizures, right hemiparesia	1+2	−	65	CR	Motor improvement; no seizures; antiepileptic drug dose reduced and antiepileptic therapy ceased after 4 years follow-up
9	12 years	F	II, R	Headache, temporal bulging, left hemiparesia	1+2	−	39	CU	Headache relieved; slight improvement in hemiparesia after repeat endoscopic fenestration (1+2+3)
10	20 months	M	III, R	Macrocrania, temporal bulging	1+2	−	50	CU	Normalized skull growth rate
11	4 years	M	III, L	Headache, temporal bulging, seizures	1+2+3	−	66	CU	Headache relieved; no seizures; antiepileptic drug dose reduced and antiepileptic therapy ceased after 4 years follow-up
12	11 years	F	III, R	Seizures, headache	1+2	−	61	CU	Headache relieved; no significant change in seizure frequency
13	6 years	F	II, R	Left hemiparesia, seizures	1+2+3	−	63	CU	Improvement in hemiparesia; reduction in seizure frequency and reduction in antiepileptic drug dose
14	32 months	M	III, L	Temporal bulging, seizures, right hemiparesia	1+2	+[a]	40	CU	No seizures with reduced antiepileptic drug dose; significant motor improvement
15	10 years	M	III, R	Headache, psychomotor retardation	1+2+3	−	25	CU	Headache relieved; no significant change in psychomotor status
16	3 years	M	II, L	Headache, temporal bulging	1+2+3	−	33	CR	Headache relieved
17	12 months	M	III, R	Macrocrania	1+2	−	49	CR	Normalized skull growth rate
18	9 years	F	III, L	Seizures, headache	1+2+3	−	39	CR	Headache relieved; no significant change in seizure frequency
19	10 months	F	III, R	Macrocrania	1+2	−	78	CR	Normalized skull growth rate
20	16 months	M	III, R	Macrocrania	1+2+3	−	48	CR	Normalized skull growth rate

1 space between the optic nerve and internal carotid artery, *2* space between the oculomotor nerve and internal carotid artery, *3* space between the oculomotor nerve and the tentorial edge, *CR* cyst size reduced, *CU* cyst size unchanged, *CP-Shunt* cystoperitoneal shunt

[a] Asymptomatic ipsilateral subdural effusion which resolved spontaneously

Results

The mean follow-up period was 53 months (range, 12–114 months). Four children presented during the follow-up period a recurrence of their symptomatology. Three of them had Galassi type III cysts and one was with Galassi type II cyst. In three cases a repeat endoscopic fenestration surgery has been performed. Two children (both with Galassi type III cysts) required "cystoperitoneal shunt" implantation. Overall, pure neuroendoscopic fenestration procedure succeeded in 18 (90%) of the 20 cases. No major vessel or nervous injury occurred. Early postoperative control CT showed an ipsilateral hemispheric subdural collection in one case. The child was asymptomatic and postoperative subdural effusion resolved spontaneously within a week. Of the 18 cases, in which the endoscopic fenestration procedure succeeded, 10 (55.5%) showed a reduction in cyst size. In the majority of cases (14/18), the flow of CSF through the cystocisternostomies was confirmed by signal voids around ICA or tentorial edge on postoperative T2-

weighted coronal MR imaging studies. The rates of resolution of the preoperative symptoms in cases in which the neuroendoscopic procedure succeeded were as follows: headache resolved in all (7/7) cases; improvement in motor deficits was observed in all cases (6/6); skull growth rate was normalized in all cases with macrocrania (6/6); and of the children, who had seizure disorders preoperatively, 50% (4/8) became seizure free with reduced or ceased anti-epileptic therapy, 25% (2/8) showed a significant reduction in seizure frequency, and 25% (2/8) showed no significant change in seizure frequency despite resolution of other symptoms postoperatively. Our series included one case with psychomotor retardation. In the postoperative follow-up period, his headache relieved but no significant change was observed in his psychomotor status.

In three cases a single fenestration site has been made for the marsupialization of the cyst. Of those cases, one failed and two required a repeat endoscopic fenestration. Of those two cases which have undergone repeat endoscopic procedure, one required cystoperitoneal shunt implantation in the end. In this group, one case showed a reduction in cyst size, which was determined after the repeat endoscopic fenestration.

In 11 cases two fenestration sites have been made for the marsupialization of the cyst. In this group, only one case required a repeat endoscopic procedure and no shunt surgery was needed in the end. Six of the 11 children in this group showed a reduction in cyst volume postoperatively.

In 6 of the 20 cases, three cystocisternotomy fenestration sites have been created for the marsupialization of the cyst. In this group, endoscopic procedure was successful in all cases with a postoperative cyst size reduction ratio of 3/6. Postoperative results of the series are summarized in Table 1.

Discussion

Congenital arachnoid cysts are intra-arachnoid collections of cerebrospinal fluid. In 1831, Bright was first to describe arachnoid cyst as a "serous cyst in the arachnoid" [3]. Incomplete separation of the perimedullary mesh (endomeninx) during the early stages of embryogenesis or duplication of the arachnoid membrane during development has been offered as the main mechanisms to explain their occurrence [1, 15, 17, 19]. There is a significant amount of evidence indicating that these lesions are developmental in nature, differentiating them from other benign cysts, such as porencephalic, leptomeningeal, and neuroepithelial cysts. They constitute 0.75–1% of nontraumatic intracranial mass lesions, with 50% to 60% occurring in the middle cranial fossa (SACs) [11, 20].

Middle fossa arachnoid cysts, generally denominated temporal cysts or Sylvian arachnoid cysts (SACs), are particularly challenging for neurosurgeons since their natural history is still unclear. The mechanism by which arachnoid cysts expand and become symptomatic is still being investigated. The potential expansion of these cysts is supposed to be multifactorial: direct secretion of fluid from the cyst lining, arterial pulsations via a one-way valve, and osmotic gradient-induced intracystic fluid accumulation [15, 24].

The management of SACs in children is still a matter of debate. As they have been increasingly diagnosed since the advent of neuroimaging, diagnosis is often incidental, and the majority of these lesions are asymptomatic at the time of diagnosis.

Suggested diagnostic investigation results have been often unclear [22]. Although the majority of these lesions are asymptomatic, they may develop into a range of signs and symptoms which frequently include headache, macrocrania, temporal bone bulging, increased intracranial pressure, epileptic seizures, hydrocephalus, and psychomotor retardation in children [12, 20]. The indications for surgical treatment of SACs in children are a matter of debate. Rationality of preemptive treatment in children or the necessity of surgical indication in patients with common and aspecific symptoms like headache is still being discussed [6, 22].

The best surgical approach for treatment of SACs also remains controversial. Options include cyst shunting, craniotomy or keyhole approach for fenestration, endoscope-controlled microneurosurgery, and pure endoscopic fenestration [8, 10, 14, 16]. Each of these techniques has particular advantages, and debate continues regarding which surgical treatment is the most effective. It is important to remember that the children with SACs are being treated for a benign condition. Avoiding significant complications associated with major surgery, including neurological deficits, subdural hematomas, or hygromas is of great importance in this group. Although shunt placement is potentially a safer option, it harbors potential risks such as infection, blockage, and more importantly, the lifelong dependence, which should not be underestimated.

Reports of endoscopic cyst fenestration were relatively rare 10 years ago, but the field has since seen a large increase in the number of surgeons who are comfortably and routinely using the endoscope to approach these lesions. Recent reports indicate that, increasing number of centers are using the endoscopic approach as the first-line management of SACs in children [8, 9, 15, 20]. However, some questions remain concerning the pure endoscopic fenestration in children which are as follows: is the pure endoscopic fenestration technique in SACs as safe and efficient as in other locations; is it technically feasible even

in very young children; is there any outcome difference between the various techniques; and are there any factors affecting the long-term efficacy of the cystocisternal fenestration(s)?

Our experience highlights the benefits of using pure endoscopic fenestration technique in the management of SACs in pediatric cases. We prefer the rigid endoscope for its superior optics, and we change the degree of the endoscope when it is necessary to see difficult angles rather than use a steerable device. Our data showed that this technique was effective in 90% of the cases and resulted in sustained good long-term outcomes with a mean follow-up period of 53 months (approximately 4 years). Of the 20 children, 6 were under 2 years of age (ranging between 7 and 20 months) in our series. Pure endoscopic fenestration technique was successful and resulted in normalized skull growth rate in all those cases. We suggest that pure endoscopic fenestration is technically feasible even in very young children. In such cases, we recommend the use of a small diameter endoscope which may allow to reach safely the planned target area.

Recently Di Rocco et al. [6] suggested that the cause–effect relationship of classical clinical manifestations of temporal arachnoid cysts appears to be quite questionable, when analyzed objectively on the grounds of the literature. For example, headache, which is reported in about 70% of symptomatic cases, may be in most instances aspecific, chronic, unrelated to the cyst volume, or to the compression exerted by the cyst [6, 22]. However, in most of the published series, cases were reported to relieve from preoperative headache following surgical decompression of the SACs [8, 20, 22]. In a recently published series of 40 patients treated endoscopically by Spacca et al. [20], headache was reported as the most likely symptom to improve, with a complete recovery or significant improvement in 93.3% of the cases. Our results also showed that preoperative headache resolved in all cases, in which the neuroendoscopic procedure succeeded. We may assume that headache in SAC cases may somehow be related to the compression/distortion of the surrounding cerebrovascular structures.

Concerning seizure disorder, the correlation with the presence of a SAC or the outcome following its surgical excision is uncertain. It was reported that, one fourth of the patients with epilepsy may have developmental cortical anomalies far from the cyst and controlateral EEG anomalies are quite common [6]. In a recent study by Di Rocco et al. [8], the authors reported that they have operated two children with huge SACs for seizures and both have improved in their seizures. Among the 18 cases, in which the endoscopic procedure succeeded, 8 children have presented with seizures in our series. Our postoperative results revealed that four of those eight children became seizure free with reduced or ceased antiepileptic therapy and two children showed a significant reduction in seizure frequency. However we observed no significant change in seizure frequency in two children despite their other symptoms resolved postoperatively. These results seem to support the comments of Di Rocco [6] about the cause–effect relationship of clinical manifestations of SACs in terms of seizure disorder.

Among the 18 cases, in which the endoscopic procedure succeeded, our series included 1 child with psychomotor retardation. In the postoperative follow-up period, his headache relieved but no significant change was observed in his psychomotor status. With regard to postoperative improvement of psychomotor retardation in SACs, the amount of available information is limited in the literature [22, 23]. So it is not possible for us to comment on this issue on the basis of the result of a single case in our series.

In the recently published series, the pure endoscopic approach has been reported to offer comparable results to shunts and craniotomy in terms of symptom control. However, the rate of radiological resolution of the cyst has been reported to be lower than in those alternative techniques [8, 9, 15, 20]. In our series, of the 18 cases, in which the endoscopic fenestration procedure succeeded, 10 (55.5%) showed a reduction in cyst size. In our data, the decision on the reduction in cyst size was based on postoperative neuroimaging studies that have been performed at least 3 months following the procedure. As suggested in previous studies, we also agree that the postoperative neuroimaging sometimes indicates a reduction in cyst size, but resolution of symptoms is the most reliable means with which to assess outcome [11]. The MR imaging modality has become an excellent tool through which to judge the success of CSF flow through fenestrations. The flow of CSF through the cystocisternostomies can be confirmed by signal voids around ICA or tentorial edge on postoperative T2-weighted coronal MR imaging studies. To judge the success of endoscopic procedure, we recommend the routine use of T2-weighted and fluid attenuated inversion recovery sequences as part of postoperative evaluations.

Four children presented during the follow-up period a recurrence of their symptomatology. In three of them only one fenestration site has been created during the first surgery. In one of those three cases (case no 3 in Table 1) instead of performing a repeat endoscopic exploration and fenestration, we have performed cystoperitoneal shunt surgery after recurrence of his symptomatology 8 months after the endoscopic surgery since we were at our early experience period for this technique. In other two children, in whom only one fenestration site has been created, the symptoms recurred 5 and 11 months following the endoscopic procedure, respectively. Both cases have undergone repeat endoscopic surgery and multiple fenestration sites have been made. In one of them (case no 7 in Table 1), there have been no

improvement even after repeat endoscopic fenestration. Among the children in whom multiple cystocisternostomy fenestrations have been made, only one (case no 4 in Table 1) had presented with the recurrence of his symptomatology during the follow-up period. He had undergone repeat endoscopic surgery 14 months after the initial procedure and three fenestration sites had been created, which resulted in resolution of his symptoms. Our results seem to reflect that there may be a correlation between the effectivity of the endoscopic fenestration procedure and the number of stomies performed during the surgery. When we reviewed the video recordings of the procedures, we noticed that the surgeons have preferred to perform multiple fenestrations in a much "aggressive" way to achieve effective openings of the deep arachnoid membranes into the basal cisterns as they have gained experience over time. Eventually, such a progress in endoscopic experience resulted in multiple and larger stomies that prevent from a secondary closure and warrant long-term efficacy of the endoscopic procedure.

Subdural hygroma is one of the main complications encountered following the surgical management of SACs. Both subdural hygromas and subdural hematomas have been reported after the treatment of SACs in children, whether microsurgical or endoscopic [2, 5, 21]. In the series of Spacca et al. [20], subdural hygroma has been reported as the main complication encountered (five patients, 12.5%), requiring surgical treatment with subduroperitoneal shunt in four cases. Recently, Di Rocco et al. [8] reported that 2 of 17 children have developed a symptomatic subdural collection and have required a transient subdural–peritoneal shunt in their series. In our series, early postoperative control CT showed an ipsilateral hemispheric subdural collection in one case. The child was asymptomatic and the subdural effusion resolved spontaneously within a week. The physiopathology of postoperative subdural effusion is still poorly understood. One of the proposed mechanisms is "the separation of the dura mater and arachnoid layers following a reduction in pressure due to an excessive perioperative loss of the cyst content". According to this mechanism, we suggest a relatively lower risk for postoperative subdural effusion in the pure endoscopic fenestration technique. Because the endoscopic opening of the cyst allows a normalization of the intracranial pressure, but the cyst will not be emptied of its content, the pressure within the cyst will, thus, be maintained during the procedure. This might decrease the risk of creating a subdural space and, consequently, might reduce the risk of an important postoperative subdural effusion.

Conclusion

We suggest that pure endoscopic approach can be used safely in the management of SACs in children. An effective opening of the deep arachnoid membranes into the basal cisterns can be performed even in very young children. Postoperative resolution of the symptoms related to increased intracranial pressure and/or improvement in neurological symptoms should be accepted as the main success criteria for the procedure. However, we recommend that the learning curve should be completed before using the pure endoscopic approach as the first-line management of SACs in children. Like other surgical techniques, the endoscopic technique requires a slow learning process during which the surgeon accumulates invaluable experience. The technical difficulty of cystocisternostomy consists in obtaining a wide opening of the deep cystic membranes and the underlying arachnoidal layer of the basal cisterns to create adequate communication. The membranes to be perforated are often multiple and tough with a consequently high risk of damaging the vascular and nervous structures. In case of the persistence or the recurrence of symptoms, a repeat endoscopic procedure can be considered especially in children with a single fenestration site. To our experience, the long-term efficacy of the endoscopic procedure seems to be correlated with multiple fenestrations which are created by successively opening of all membranes to ensure a good in- and outflow. We recommend at least two fenestration sites for an effective marsupialization of the cyst within the basal cisterns.

References

1. Balsubramaniam C, Laurent J, Rouah E, Armstrong D, Feldstein N, Schneider S, Cheek W (1989) Congenital arachnoid cysts in children. Pediatr Neurosci 15:223–228
2. Beems T, Grotenhuis JA (2004) Long-term complications and definition of failure of neuroendoscopic procedures. Childs Nerv Syst 20(11–12):868–877
3. Bright R (1831) Reports of medical cases selected with a view of illustrating the symptoms and cure of diseases by a reference to morbid anatomy. In: Longman, Rees, Orme et al (eds) Diseases of the brain and nervous system, vol 2. Highley, London, pp 593–660
4. Choi JU, Kim DS, Huh R (1999) Endoscopic approach to arachnoid cyst. Childs Nerv Syst 15(6–7):285–291
5. Cinalli G, Spennato P, Ruggiero C, Aliberti F, Trischitta V, Buonocore MC, Cianciulli E, Maggi G (2007) Complications following endoscopic intracranial procedures in children. Childs Nerv Syst 23(6):633–644
6. Di Rocco C (2010) Sylvian fissure arachnoid cysts: we do operate on them but should it be done? Childs Nerv Syst 26:173–175
7. Di Rocco C, Caldarelli M, Ceddia A (1993) Incidence, anatomical distribution, and classification of arachnoidal cysts. In: Raimondi A, Choux M, Di Rocco C (eds) Intracranial cyst lesions. Springer, New York, pp 101–111
8. Di Rocco F, James SR, Roujeau T, Puget S, Sainte-Rose C, Zerah M (2010) Limits of endoscopic treatment of Sylvian arachnoid cysts in children. Childs Nerv Syst 26:155–162

9. Elhammady MS, Bhatia S, Ragheb J (2007) Endoscopic fenestration of middle fossa arachnoid cysts: a technical description and case series. Pediatr Neurosurg 43(3):209–215
10. Godano U, Mascari C, Consales A, Calbucci F (2004) Endoscope-controlled microneurosurgery for the treatment of intracranial fluid cysts. Childs Nerv Syst 20(11, 12):839–841
11. Greenfield JP, Souweidane MM (2005) Endoscopic management of intracranial cysts. Neurosurg Focus 19(6):E7
12. Helland CA, Wester K (2006) A population-based study of intracranial arachnoid cysts: clinical and neuroimaging outcomes following surgical cyst decompression in children. J Neurosurg 105:385–390
13. Hopf NJ, Pernezski A (1998) Endoscopic neurosurgery and endoscope-assisted microneurosurgery for the treatment of intracranial cysts. Neurosurgery 43(6):1330–1336
14. Kang JK, Lee KS, Lee IW, Jeun SS, Son BC, Jung CK, Park YS, Lee SW (2000) Shunt-independent surgical treatment of middle fossa arachnoid cysts in children. Childs Nerv Syst 16:111–116
15. Karabatsu K, Hayhurst H, Buxton N, O'Brien DF, Mallucci CL (2007) Endoscopic management of arachnoid cysts: an advancing technique. J Neurosurg 106:455–462
16. Levy ML, Wang M, Aryan HE, Yoo K, Meltzer H (2003) Microsurgical keyhole approach for middle fossa arachnoid cyst fenestration. Neurosurgery 53(5):1138–1144
17. Passero S, Filosomi G, Cioni R, Venturi V, Volpini B (1990) Arachnoid cysts of the middle cranial fossa: a clinical, radiological and followup study. Acta Neurol Scand 82:94–100
18. Rengachary S, Watanabe T (1981) Ultrastructure and pathogenesis of intracranial arachnoid cysts. J Neuropathol Exp Neurol 40:616–663
19. Santamarta D, Aguas J, Ferrer E (1995) The natural history of arachnoid cysts: endoscope and cine-mode MRI evidence of a slit-valve mechanism. Minim Invasive Neurosurg 38:133–137
20. Spacca B, Kandasamy J, Mallucci CL, Genitori L (2010) Endoscopic treatment of middle fossa arachnoid cysts: a series of 40 patients treated endoscopically in two centres. Childs Nerv Syst 26:163–172
21. Tamburrini G, Caldarelli M, Massimi L, Santini P, Di Rocco C (2003) Subdural hygroma: an unwanted result of Sylvian arachnoid cyst marsupialization. Childs Nerv Syst 19(3):159–165
22. Tamburrini G, Fabbro MD, Di Rocco C (2008) Sylvian fissure arachnoid cysts: a survey on their diagnostic workout and practical management. Childs Nerv Syst 24:593–604
23. Wester K, Hugdhal K (1995) Arachnoid cysts of the temporal fossa: impaired preoperative cognition and postoperative improvement. J Neurol Neurosurg Psychiatry 59:293–298
24. Zada G, Krieger MD, McNatt SA, Bowen I, McComb JG (2007) Pathogenesis and treatment of intracranial arachnoid cysts in pediatric patients younger than 2 years of age. Neurosurg Focus 22(2):E1