Child's Nerv Syst (1999) 15:285–291

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Endoscopic approach to arachnoid cyst

Received: 30 December 1998

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Abstract A prospective study of 36 consecutive patients with congenital arachnoid cysts treated endoscopically is reported. There were 15 female and 21 male patients. The mean age at the time of diagnosis was 12.3 years (10 days to 38 years). Arachnoid cysts were located in the suprasellar region in 16 patients, the sylvian fissure in 11, the quadrigeminal cistern in 4 and the posterior fossa in 5. Endoscopic fenestration was combined with cysto-peritoneal shunting for 6 temporal cysts and with ventriculo-peritoneal shunting in 1 suprasellar cyst. Mean postoperative follow-up was 4.2 years (range 1–8 years). Follow-up imaging studies showed that 28 arachnoid cysts (77.8%) were obliterated after endoscopic procedures. Long-term clinical results were good in all patients, although the cysts of 8 patients were not reduced in size. There was no mortality or morbidity. We conclude that endoscopic procedures may be a promising alternative to microsurgical operations or shunting for the treatment of arachnoid cysts.

Key words Arachnoid cyst · Cysto-peritoneal shunt · Endoscopic procedure

Introduction

Arachnoid cysts are encountered clinically with relatively high frequency. Arachnoid cysts are a pathologic condition in which an arachnoid-lined cavity is filled with a CSF-like fluid, often creating a disturbance in intracranial dynamics owing to shifting and displacement of surrounding structures as well as intracranial hypertension [21, 29]. Numerous operative procedures have been recommended, including stereotactic aspiration, cyst excision, cyst fenestration, cysto-cisternostomy, ventriculocystostomy, and cysto-peritoneal shunting. However, it remains controversial which is the best method. Recently, the introduction of neuroendoscopy has provided neurosurgeons with a new technique for the treatment of arachnoid cysts.

We report our experience with a series of 36 consecutive patients with arachnoid cysts treated endoscopically and discuss different approaches according to the location of the cysts.

Patients and methods

Characteristics of patients

From January 1990 to January 1997, we treated 36 patients harboring intracranial arachnoid cysts by endoscopic techniques. There were 15 female and 21 male patients. The age of the patients ranged from 10 days to 38 years; their mean age at the time of diagnosis was 12.3 years. Thirty-one patients were in the pediatric age group (under the age of 18 years). Their symptoms had already lasted for from 3 months to 7 years. The clinical presentations were characterized by signs of increased intracranial pressure (headache, vomiting, drowsiness, bulging fontanel, and large head) in 30 patients, seizure in 4, visual disturbance in 4, cerebellar ataxic gait in 3, and developmental delay in 2. A prospective study of each case was performed, including neurological examinations, MR imaging and cine-MR before surgery and again at 6, 12 and 24 months postoperatively.

Diagnostic work-up

Computerized tomography and MR imaging demonstrated a mass effect of the cysts on neighboring brain tissue, with flattening of

gyri and compression of the ventricular system. Arachnoid cysts were located in the suprasellar region in 16 patients, the sylvian fissure in 11, the quadrigeminal cistern in 4 and the posterior fossa in 5. All suprasellar cysts and quadrigeminal cysts produced hydrocephalus. Two posterior fossa cysts were also combined with hydrocephalus. Follow-up cine-MR was useful in confirming the reconstruction of the normal CSF pathway or new pathways between cysts and normal CSF spaces.

Operative procedures

We performed 36 endoscopic procedures. Endoscopic fenestration was combined with cysto-peritoneal shunting for 6 temporal arachnoid cysts and with ventriculo-peritoneal shunting for 1 suprasellar arachnoid cyst, which were our initial cases. Recently, we have preferred endoscopic fenestration without additional procedures regardless of the location. For the treatment of hydrocephalus in 4 quadrigeminal arachnoid cysts, endoscopic III ventriculostomy was combined with endoscopic ventriculo-cystostomy.

Instrumentation consisted of a 30° Hopkins pediatric rigid telescope (Karl Storz, Germany) with an outside diameter of 2.7 mm, a telescope sheath with an outside diameter of 3.8 mm, a stylet, a Nd-Yag laser system, a fiberoptic light guide, a Xenon light source and an endovision system. We preferred a rigid telescope, but a steerable endoscope was used sometimes for viewing such intraventricular structures as the aqueduct of Sylvius. The Nd-Yag laser system was used on a low-wattage setting to incise the cyst wall or to shrink the cyst to a smaller size. This made it possible to remove the cyst wall and/or create a CSF communication between the cyst and normal CSF pathways. An irrigation system with a warm normal saline solution introduced via the telescope sheath was useful and essential in maintaining clear vision during endoscopic procedures. However, we tried stopping irrigation from time to time to observe bulging of the cyst wall, which makes it easy to incise the wall without damaging the structures below. All procedures were performed under general anesthesia. The position of patients and draping were selected to allow immediate open microsurgical intervention or shunting. A burr hole was made according to the best trajectory obtained by MR imaging.

Transventricular approach for suprasellar and quadrigeminal arachnoid cysts

The best point to make a burr hole for suprasellar lesions was 1 cm in front of the coronal suture and 2–3 cm lateral to the midline. This burr hole was just in front of that for endoscopic III ventriculostomy, which made it easy to view the aqueduct of Sylvius. The right lateral ventricle was tapped using a ventricular catheter through the burr hole. The tip of the tapping catheter was directed to the glabella and tragus of the right ear. A peelaway catheter was replaced via the tract. The telescope is then advanced with its sheath into the lateral ventricle through the peelaway catheter. We identified that the foramen of Monro was completely obstructed by a huge arachnoid cyst (Fig. 1A). We incised the cyst wall with a Nd-Yag laser set on a low (30 W) wattage (Fig. 1B). We could immediately confirm the back-flow of CSF across the cystostomy and reopened the foramen of Monro. The diameter of a defect created in this way was usually 3–5 mm. This defect should be enlarged as a longitudinal slot at least 10 mm in its maximum dimension, using a similar technique, dot-to-dot fenestration, or incision of the cyst wall. Wide fenestration, creating defects greater than 10 mm in the cyst walls, has proved very desirable to avoid subsequent reclosure (Fig. 1C). An elliptical incision can also be made to excise the central portion for biopsy purposes (Fig. 1D). Passing the telescope through the opening ensures communication between the cyst and ventricular system (ventriculo-cystostomy). The telescope was then advanced through the site of cystostomy to visualize the floor of the III ventricle. This made it possible for us to observe all the anatomical structures around the interpeduncular cistern through the thin inner layer of the arachnoid cyst, such as the basilar artery, internal carotid artery, posterior communicating arteries, pituitary stalk, optic chiasm, and IIIrd cranial nerves (Fig. 1E). We thought that an additional III ventriculostomy would be unnecessary. We coagulated the surface of the cyst wall to shrink the cyst using a Nd-Yag laser and finished the procedure after confirmation that the aqueduct of Sylvius was patent (Fig. 1F). We could see notable signal voids through the aqueduct on postoperative T2-weighted MR imaging (Fig. 4A, B).

Burr holes made to allow an approach to quadrigeminal cysts were the same as those for suprasellar cysts. The foramen of Monro was identified, and the telescope was then advanced through the foramen to visualize the floor of the III ventricle. We could observe the dilated III ventricle and any obstruction in the form of aqueductal stenosis caused by quadrigeminal arachnoid cysts. A cyst bulging into the floor of the lateral ventricle was incised using the Nd-Yag laser in the same manner. When the telescope was advanced into the cyst though the opening, we could see the deep venous system including the internal cerebral vein, the vein of Rosenthal and the straight sinus.

We simultaneously performed III ventriculostomy in addition to ventriculo-cystostomy, because a long-standing quadrigeminal cyst could have produced aqueductal stenosis.

The site for III ventriculostomy was located in the midline in front of the two mamillary bodies, which was about 2/3 posterior between the infundibular recess and the dome of the basilar artery. The dome of the basilar artery was visualized between the two mamillary bodies. To perforate the III ventricular floor, a monopolar electrode was advanced via the working channel of the sheath. Monopolar electro-coagulation could easily perforate the floor of the III ventricle under direct vision. The flow of CSF through the hole was usually seen after perforation. The hole was enlarged by insertion of the telescope, and the basilar artery in the interpeduncular cistern was usually inspected.

Approach for temporal arachnoid cysts

In approaching sylvian cysts, more laterally located burr holes were needed. These were made on the coronal suture and 5–6 cm lateral to the midline or just below the sylvian fissure. Care was needed to ensure that the trajectory of endoscopic approach was not across the sylvian fissure, to prevent major hemorrhaging from the middle cerebral artery and its branches. The cyst was tapped using a ventricular catheter through the burr hole. When the burr hole was on the parenchyma of the cerebral cortex great care was taken, because it was often difficult to tap the outer membrane of cysts. The tip of the tapping catheter was directed to the tragus of the contralateral ear. The peelaway catheter was replaced via the tract, and then the telescope was advanced into the arachnoid cyst through the peelaway catheter. After advancing the endoscope along the sphenoid ridge, we could observe the optic nerve and internal carotid artery and its branches (Fig. 2A,B). The inner membrane of the cyst was cut with a Nd-Yag laser. Communication between the cyst and basal cistern (cysto-cisternostomy) was made on the Liliequist membrane, between the IIIrd cranial nerve and ICA or lateral to the IIIrd cranial nerve (Fig. 2C). The site of incision depends on the angle or working space for the endoscopic procedure. We enlarged the opening by insertion of the telescope and noted the basilar artery in the interpeduncular cistern (Fig. 2D). The flow of CSF through the opening was usually seen after cystostomy, which was confirmed by signal voids around ICA on postoperative T2-weighted coronal MR imaging (Fig. 4C,D).

Suboccipital approach for posterior fossa cysts

Burr holes were made on the paramedian area 1 cm lateral to the midline and below the transverse sinus. Cysts were tapped and in-

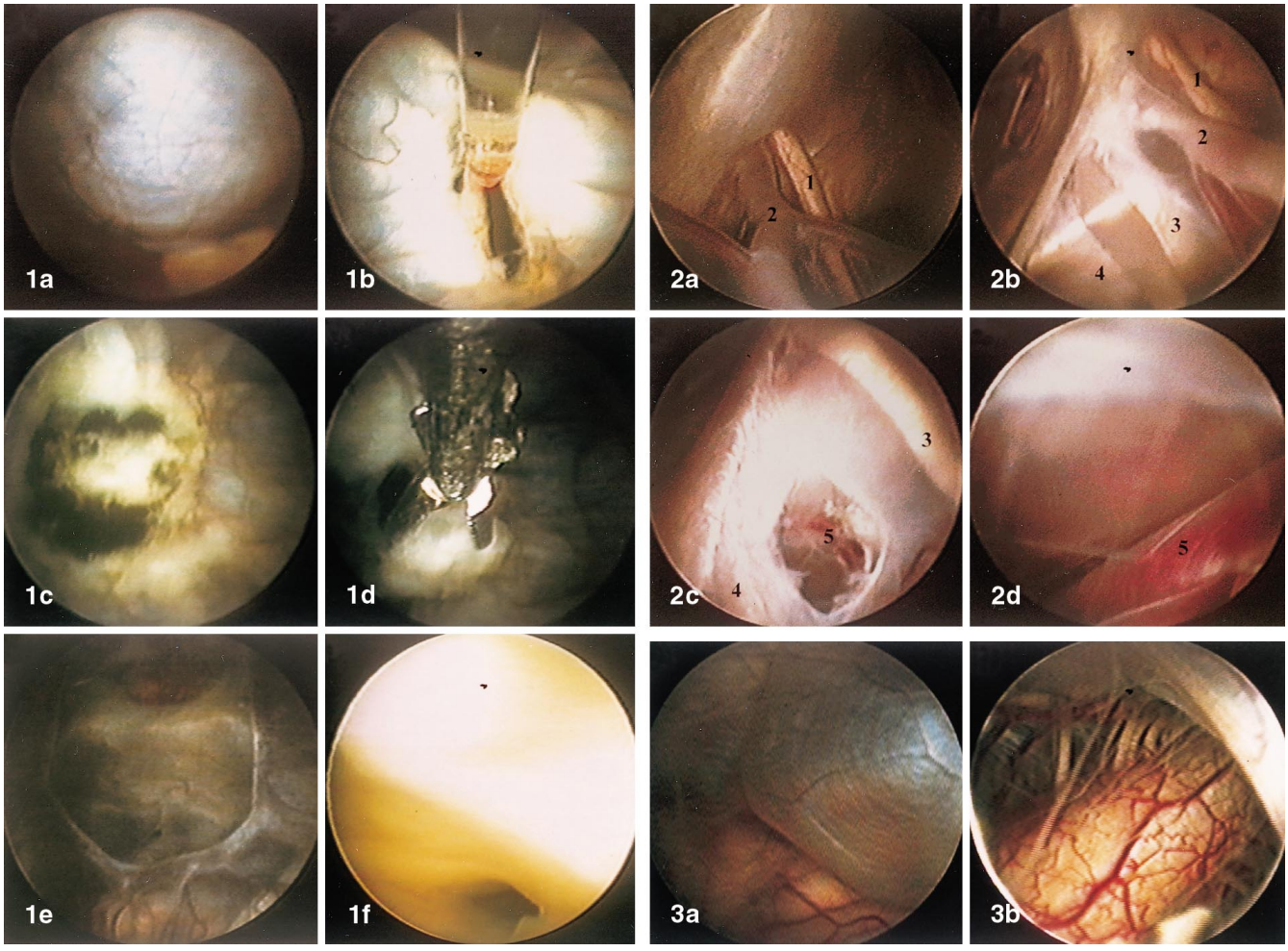

Fig. 1a–f Endoscopic findings with transventricular approach to suprasellar arachnoid cysts. **a** Endoscopic view in the right lateral ventricle. Cyst is bulging through the foramen of Monro. **b** Cyst wall was incised using a Nd-Yag laser. **c** Fenestration is extended in elliptical fashion. **d** Biopsy of the cyst wall. **e** Intracystic endoscopic views, with anatomical structures around the interpeduncular cistern seen through the thin inner layer of the arachnoid cyst: basilar artery, internal carotid artery, posterior communicating arteries, pituitary stalk, optic chiasm, and the IIIrd cranial nerves etc. **f** Patent aqueduct of Sylvius

Fig. 2a–d Endoscopic findings in the left temporal arachnoid cyst. **a** Intra-cystic view: the optic nerve (*1*) and internal carotid artery and its branches (*2*) are seen. **b** Close-up view: the IIIrd (*3*) and IVth cranial nerves (*4*). **c** Fenestration from the cyst into basal cistern (cysto-cisternostomy) is made at lateral portion to the IIIrd cranial nerve. **d** The basilar artery (*5*) in the interpeduncular cistern

Fig. 3a, b Suboccipital approach for posterior fossa cysts. **a** Intracystic view. Cyst wall is bulging out from cisterna magna following decompression of cyst by endoscope insertion and drainage of cyst content. **b** Endoscopic view after cysto-cisternostomy. Upper cervical cord and roots are seen through fenestration

cised with the same techniques as above. A cysto-cisternostomy was made between the cyst and quadrigeminal cistern or cisterna magna. We preferred fenestration into the cisterna magna, which has a wider CSF space and a less important vein than the quadrigeminal cistern does. We were able to inspect the spinal cord, medulla oblongata, lower cranial nerves, posterior inferior cerebellar artery and its branches, and the IV ventricle though the opening to the cisterna magna (Fig. 3). Postoperative T2-weighted MR imaging showed signal voids through opening between the cisterna magna and cyst and enlarged prepontine cistern space (Fig. 4E,F).

Results

The mean postoperative follow-up was 4.2 years, ranging from 1 to 8 years. Long-term clinical results were good in all patients (Table 1). There was no mortality or morbidity in our series. Postoperative cine-MR showed free communication of CSF between cysts and normal CSF spaces, such as ventricles or cisterns (Fig. 4). Follow-up imaging studies showed that 28 out of 36 arachnoid cysts (77.8%) were reduced in size after endoscopic procedures. All suprasellar cysts, 3 posterior fossa cysts,

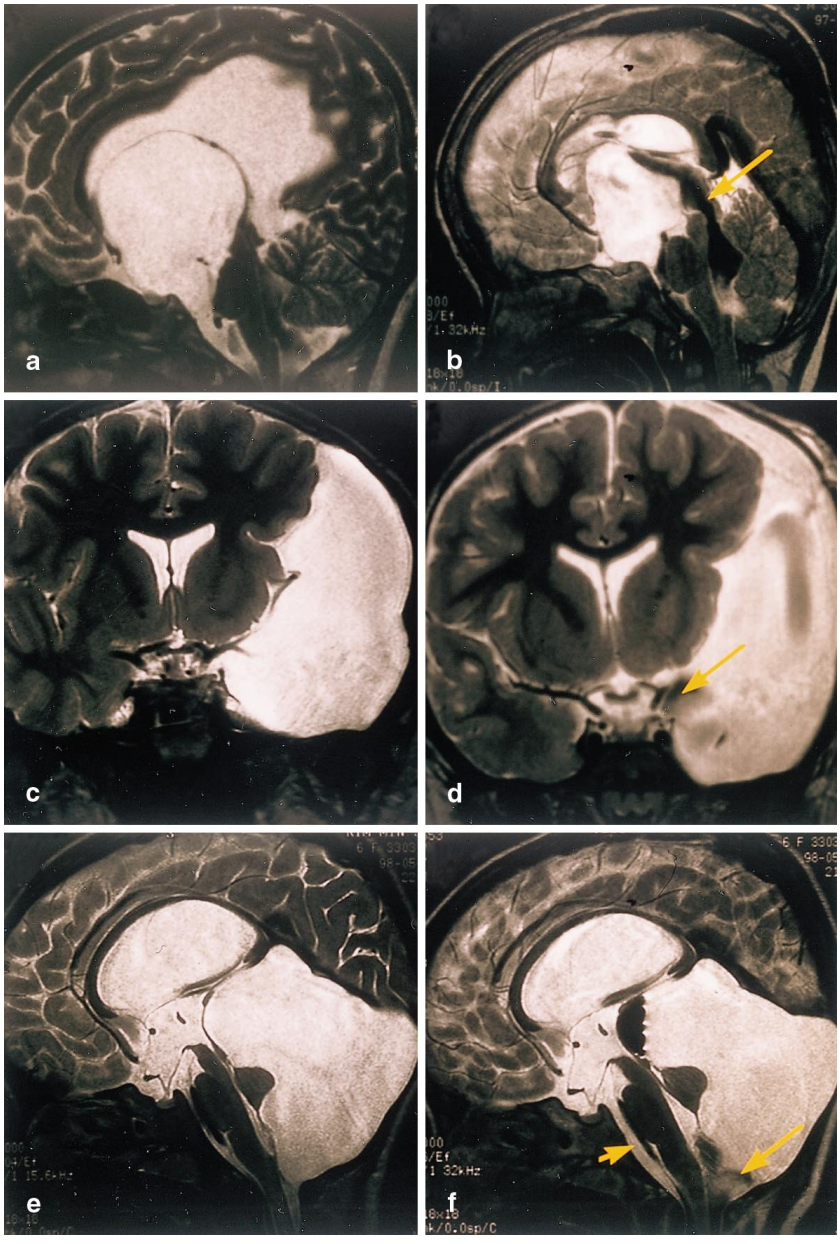

Fig. 4 **a** Preoperative MRI of the suprasellar arachnoid cyst. **b** Postoperative T2-weighted MRI shows reduction of cyst size and notable signal voids through the aqueduct. **c** Preoperative MRI of the sylvian arachnoid cyst. **d** MRI taken on 7th day after fenestration. The signal void is seen through opening between the chiasmatic cistern and cyst. **e** Preoperative MRI of the posterior fossa arachnoid cyst. **f** T2-weighted MR imaging taken on 7th day after endoscopic surgery, showing signal voids through opening between the cisterna magna and cyst (*large arrow*) and enlarged prepontine cistern (*small arrow*)

Table 1 Outcome of arachnoid cysts after endoscopic treatment. Long-term clinical results were good regardless of the surgical procedures in all patients (*CP* cystoperitoneal)

Location of arachnoid cyst	Treatment modality	No. of patients	Reduction of cyst size
Suprasellar	Ventriculo-cystostomy	16	16 (100%)
Sylvian fissure	Cysto-cisternostomy	5	3 (60%)
	Cysto-cisternostomy+CP shunting	6	6 (100%)
Quadrigeminal cistern	Ventriculo-cystostomy+III ventriculostomy	4	3 (75%)
Posterior fossa	Cysto-cisternostomy	5	3 (60%)

and 3 quadrigeminal cysts were markedly reduced. However, 2 posterior fossa cysts and 1 quadrigeminal cyst were only slightly reduced in size. Five temporal cysts that were treated with an endoscopic procedure only were slightly reduced, while 6 temporal cysts treated with an endoscopic procedure combined with cysto-peritoneal shunting were completely obliterated. The symptoms and signs of hydrocephalus in all 25 patients except 1 were resolved without shunting. One patient with a suprasellar arachnoid cyst suffered intraventricular hemorrhage, which probably resulted from sudden CSF drainage during the endoscopic procedure. This patient needed extraventricular drainage followed by ventriculo-peritoneal shunting. The patient recovered without any neurological deficits.

Discussion

In this era of modern imaging, the diagnosis of arachnoid cysts has become easier. Arachnoid cysts comprise about 1% of intracranial tumors and are being discovered incidentally on computed tomography and MRI in asymptomatic patients. However, the development, natural history and treatment of this lesion remain controversial.

Arachnoid cysts most probably arise by way of anomalous splitting and duplication of the endomeninx [3]. Numerous reports have also indicated the developmental anomalies of these cysts [23, 29]. It is now usually accepted that primary or congenital arachnoid cysts are maldevelopmental anomalies and should be differentiated from secondary arachnoid cysts that have resulted from a variety of such etiologies as traumas and infections [7, 10, 17, 18]. In 1964, Robinson [23] considered sylvian arachnoid cysts to be secondary fluid collections associated with temporal lobe agenesis. He suggested that the absence of brain tissue could lead to a difference in brain volume between the two hemispheres and result in the development of an arachnoid cyst. However, a postmortem study based on brain volume could not confirm such a difference [27]. A recent study using PET indicated potential metabolic recovery of the temporal lobe after treatment [9]. Moreover, the compressed temporal lobe, even if it was thought to be agenetic with a huge arachnoid cyst, as in our series, completely recovered to a normal volume after cystoperitoneal shunting [16, 20]. These results indicate that arachnoid cysts are at least not secondary lesions that have resulted from a loss of brain tissue.

Improved understanding of the natural history is essential for rational therapy. The presenting symptoms and signs are closely related to the expansion of arachnoid cysts. The mechanism by which arachnoid cysts expand is not known. A minimally higher sodium or protein content would produce an osmotic gradient that could cause the cyst to expand [15]. This is unlikely, as the contents of the cyst are usually chemically indistinguishable from CSF. Arterial pulsations via a one-way valve mechanism at the point of communication may be another possible mechanism of cyst growth, which has been confirmed during endoscopic procedures by several authors [4, 24, 25], who identified a slit-valve mechanism in the arachnoid next to the basilar artery during endoscopic intervention. Although some authors have suggested that a valve action exists only in traumatic cysts [18], recent endoscopic observations suggest that congenital cysts can also expand by this mechanism. We also identified this slit-valve mechanism in 1 patient with congenital suprasellar arachnoid cyst during the endoscopic procedure. However, we cannot be sure that the slit-valve mechanism is one unique to cyst growth, as we cannot find any opening of communication between the cyst and arachnoid space in other patients treated with endoscopy. Fluid may be secreted directly into the cyst by arachnoidal cells making up its wall [14] or by ectopic choroid-like structures [8]. It is true that these cells have been shown to contain all of the organelles and enzymes of a secretory cell [14]. However, our experience in the treatment of cystoperitoneal shunt infection makes it hard to believe that all intracystic fluid is secreted by arachnoidal cells. The intracystic fluid drained via an externalized shunt catheter had all of characteristics of CSF, and the amount was 300–500 ml per day. This amount was equal to the daily production of CSF. The growing mechanism of arachnoid cysts is still a mystery and should be studied in more depth. Therapy has focused on continuous clearing up of any localized accumulation of CSF. Several reports about spontaneous regression of arachnoid cysts may provide a clue to the solution of the above problem. The mechanism of spontaneous regression is not fully understood. One possible cause that has been considered is communication between cysts and subarachnoid cysts. It is well known that arachnoid cysts can be complicated by subdural hematomas, which result from injury to cyst surface vessels; these last are particularly susceptible even when minor head traumas are sustained. The same mechanism may be responsible for tearing of the cyst wall, which allows communication between cysts and subarachnoid cysts, and in this case the cyst will regress. Yokoyama and associates showed a communication of this type by scintigraphy in one patient with an arachnoid cyst complicated by subdural hematoma [30]. Communications between cysts and normal CSF pathways can easily be made by endoscopic procedures.

There is some controversy about the indications for treatment of arachnoid cysts. There is no doubt that surgical treatment is necessary in patients with increased intracranial pressure and corresponding clinical symptoms. However, some authors have suggested that in children, asymptomatic arachnoid cysts that exert a mass effect should be treated [11, 25, 26]. The potential

for hindering normal development and function of the adjacent brain in this group outweighs the risk of operative treatment [13, 16, 26]. Moreover, some asymptomatic arachnoid cysts may expand [15, 20] or cause significant clinical manifestations [19]. However, most neurosurgeons seem to agree that asymptomatic cysts without a brain shift or increased intracranial pressure should be managed conservatively [12, 15]. Our experience of asymptomatic arachnoid cysts during the long-term follow-up also leads us to hesitate before deciding on surgery.

Arachnoid cysts have most commonly been treated by marsupialization or by cysto-peritoneal shunting [8, 12, 15, 22]. However, controversy continues over which surgical treatment is best. We believe that complete removal of the cyst wall is not possible and is in any case unnecessary. Partial excision of the arachnoid cyst and opening of the basal cisterns or ventricles has proved to be an effective and safe procedure. Open surgery for removal or fenestration is considered too aggressive. In fact, operative mortality and morbidity are not infrequently reported [1]. Major complications of open surgery have included meningitis, hemiparesis, oculomotor palsy, subdural hematomas, seizure, and even death [1, 5, 6]. Moreover, an operation is not always effective and recurrence of the cysts has also been reported [5, 28]. The shunting procedure has also proved to be a simple and effective way of eliminating cysts. Cysto-peritoneal shunting will be the best option for the treatment of a large cyst in an infant or a young child. Although shunting is safer than open surgery, it can also sometimes lead to complications, such as obstruction, infection, unexpected hemorrhage and life-long shunt dependence [2, 22]. Moreover, shunting is very difficult in suprasellar or posterior fossa cysts.

Endoscopic treatment of arachnoid cysts has rarely been reported in the literature [4, 22, 24–26], and most authors have published sporadic cases without details of the endoscopic technique, complications, and outcome. Rappaport [22] discussed four procedures for suprasellar cyst: subfrontal fenestration of the cyst to the basal cistern, transcallosal fenestration into the lateral ventricle with shunting, cystoperitoneal shunting, and percutaneous ventriculo-cystostomy. He concluded that percutaneous ventriculo-cystostomy had the lowest incidence of reoperation and thus offered the best chance of definitive treatment. In this series, endoscopic procedures via a minimally invasive burr hole approach proved to be an effective and safe technique.

We preferred a rigid telescope, but a steerable endoscope was useful for changing the direction of view in manipulating the intraventricular structures such as the aqueduct of Sylvius. Although a steerable endoscope is inferior to a rigid telescope in optical quality, it has the advantage of changing the view angle.

We used a Nd-Yag laser system on a low-wattage setting to incise the cyst wall or to shrink the cyst to a smaller size without any additional catheter. Schroeder and associates [26] perforated the cyst wall by bipolar coagulation and enlarged the perforated hole with a Fogarty catheter, and then inserted a fimbrial catheter to prevent closure of the opening. We did not find any case of reclosure of the fenestration site in any of the patients who underwent successful endoscopic procedure without hemorrhage or infection. We think that reclosure of the fenestration site may be related to hemorrhage or infection. In our early experience, 1 patient with ventricular hemorrhage during the endoscopic procedure needed shunting later in spite of successful endoscopic ventriculo-cystostomy. We think that if there have been no unexpected hemorrhages or infections during the endoscopic procedure, an additional catheter will not be necessary.

Endoscopic procedures also offer a chance of finding abnormal intraventricular pathology, such as aqueductal stenosis. In quadrigeminal arachnoid cysts the obstructive hydrocephalus may result from the cyst itself, but can also arise from aqueductal stenosis. Obstructive hydrocephalus resulting from the cyst itself may be resolved by a microsurgical approach. However, when long-standing quadrigeminal arachnoid cysts are complicated by aqueductal stenosis, shunting for the treatment of hydrocephalus will be needed. In these cases, endoscopic III ventriculostomy was the best choice for treatment of hydrocephalus. In this series, all the hydrocephalus associated with cysts could have been treated with endoscopic techniques alone.

The objective of treatment for arachnoid cysts is the relief of pressure from an expanding cyst. In our early experience, we simultaneously performed cystoperitoneal shunting in addition to cysto-cisternostomy in 6 temporal arachnoid cysts. The temporal cysts treated with endoscopic procedure combined with cystoperitoneal shunting were completely obliterated. However, 5 temporal cysts treated with an endoscopic procedure only showed the same surgical outcome. We suggest that an endoscopic procedure can produce the same surgical outcome as shunting without the complications, although it tends to be less effective in reducing the size of a cyst. We now prefer endoscopic fenestration without additional procedures, regardless of the location. But a symptomatic small arachnoid cyst at the hemispheric, temporal and posterior fossa location will be a candidate for direct microsurgical operation. In these cases it is difficult to fenestrate the cistern by an endoscopic technique.

We believe that endoscopic procedures offer the opportunity of understanding arachnoid cyst physiology better and the advantage of avoiding a large craniotomy or the known complications of a cystoperitoneal shunt.

On the basis of our experience, we conclude that endoscopic procedures may be a promising alternative to microsurgical operation or shunting for the treatment of arachnoid cysts. We recommend an endoscopic approach as the therapy of first choice for most arachnoid cysts. Symptomatic small cysts in the hemispheric, temporal or posterior fossa region will be candidates for direct microsurgical operation. Cysto-peritoneal shunting would be an option for the treatment of large cysts in infants or young children.

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