ARACHNOID CYSTS ACCOUNT FOR 1% OF ALL INTRACRANIAL LESIONS. QUADRIGEMINAL ARACHNOID CYST (QAC) ACCOUNTS FOR 5%–10% OF ALL INTRACRANIAL ARACHNOID CYSTS. THE MANAGEMENT OF THESE CYSTS IS CHALLENGING, AND THEIR OPTIMAL SURGICAL TREATMENT IS CONTROVERSIAL. THIS STUDY EVALUATES THE ROLE OF ENDOSCOPY IN THE TREATMENT OF QACs IN CHILDREN, FOCUSING ON SOME FACTORS OR TECHNICAL ASPECTS THAT MIGHT INFLUENCE THE OUTCOME.

METHODS. Eighteen children with symptomatic QACs were the subject of this study. The group included 10 boys and 8 girls, with a mean age of 2.5 years. All patients had hydrocephalus. Surgical treatment included ventriculocystostomy (14 cases), endoscopic third ventriculostomy (14 cases), ventriculocystocisternostomy (2 cases), cystocisternostomy (2 cases), and removal of preexisting malfunctioning cystoperitoneal shunt (4 cases).

Results. Significant clinical improvement occurred in 15 cases (83.3%). Postoperative MRI showed a reduction in the cyst size in 14 cases (77.8%), whereas in the remaining 4 cases (22.2%) the cyst size was unchanged. A postoperative decrease in ventricular size was encountered in 16 cases (88.9%). Minor intraoperative bleeding occurred in 1 case (5.6%), which stopped spontaneously without any postoperative sequelae. Postoperative subdural hygroma occurred in 3 cases (16.7%) and required a subdural-ventriculoperitoneal shunt in 2 cases. During follow-up (mean 45.8 months), a repeat endoscopic procedure was performed in 7 patients (all 4 patients with a prior shunt and 3 patients without a prior shunt), and new shunt placement was required in 5 patients (all 4 patients with a prior shunt and 1 patient without a prior shunt). Thus, none of the patients with a prior shunt was able to become shunt independent, whereas 92.9% of patients without a prior shunt were able to avoid shunt placement.

Conclusions. Arachnoid cysts of the quadrigeminal cistern and the associated hydrocephalus can be effectively treated by endoscopy. The procedure is simple, minimally invasive, and associated with low morbidity and mortality rates. The fact that all patients who previously received shunts required a repeat endoscopic procedure and that none of these patients was able to become shunt independent makes it clear that endoscopic treatment should be considered the first choice in the management of patients with arachnoid cysts in the quadrigeminal cistern.

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KEY WORDS • QUADRIGEMINAL ARACHNOID CYST • ENDOSCOPY • TECHNIQUE • ENDOSCOPIC THIRD VENTRICULOSTOMY • VENTRICULOCYSTOSTOMY • VENTRICULOCYSTOCISTERNOSTOMY • CYSTOCISTERNOSTOMY

ARACHNOID CYSTS ACCOUNT FOR 1% OF ALL INTRACRANIAL LESIONS. QUADRIGEMINAL CISTERN ARACHNOID CYSTS (QACs) ARE RARE, ACCOUNTING FOR 5%–10% OF ALL INTRACRANIAL ARACHNOID CYSTS. ALTHOUGH THE CLINICAL AND RADILOGICAL FEATURES OF THESE CYSTS ARE WELL DESCRIBED IN THE LITERATURE, CONTROVERSY REMAINS CONCERNING THE BEST OPERATIVE TREATMENT. THERE ARE SEVERAL SURGICAL PROCEDURES AVAILABLE FOR QACs, INCLUDING STEREOTACTIC ASPIRATION, CRANIOTOMY AND CYST EXCISION OR FENESTRATION, VENTRICULOPIERONEAL OR CYSTOPERITONEAL SHUNTING, AND COMBINED PROCEDURES. ENDOSCOPY HAS BEEN RECENTLY CONSIDERED TO BE A BETTER SURGICAL OPTION BECAUSE IT MAINTAINS THE BASIC SURGICAL STRATEGY OF MARSUPIALIZATION WITHOUT THE INVASIVENESS OF OPEN CRANIOTOMY, WHILE AVOIDING THE COMPLICATIONS CAUSED BY SHUNT TREATMENT. ALTHOUGH QACs ARE ESPECIALLY AMENABLE TO ENDOSCOPIC TREATMENT BECAUSE THEY USUALLY HAVE AN AREA OF CONTIGUITY WITH THE VENTRICULAR SYSTEM AND/OR SUBARACHNOID CISTERNAS AND BECAUSE OF THE HYDROCEPHALIC CHANGES THEY CREATE, EXPERIENCE WITH ENDOSCOPY IN THE TREATMENT OF THESE LESIONS REMAINS LIMITED. THERE ARE MANY STUDIES THAT HAVE DISCUSSED THE ROLE OF ENDOSCOPY IN THE TREATMENT OF INTRACRANIAL ARACHNOID CYSTS, INCLUDING SOME CASES OF QACs, BUT ONLY A FEW STUDIES SPECIFICALLY ADDRESS ENDOSCOPIC TREATMENT OF QACs. THE PURPOSE OF THIS STUDY IS TO EVALUATE THE
long-term outcome of endoscopic treatment of QACs in children, focusing on some factors that might influence the outcome and accordingly may help guide surgical decision making.

**Methods**

**Study Population**

Eighteen pediatric patients with symptomatic QACs were studied during the period between March 2003 and June 2011 at Cairo University. A full medical history was obtained, and patients were subjected to a complete neurological examination, including developmental milestones. Preoperative CT scans and MR images were reviewed with special attention given to the size of the cyst; its relationship to the ventricular system and subarachnoid cisterns; its extension superiorly to the interhemispheric area, inferiorly to the infratentorial space, or laterally to the temporal fossa; the presence of mass effect, such as compression of the dorsal midbrain; and the presence of hydrocephalus or other associated congenital anomalies such as porencephaly or holoprosencephaly.

All patients underwent operations using general anesthesia via a purely endoscopic procedure. The operating room and equipment are arranged to provide maximum comfort for the surgeon (Fig. 1). All patients underwent operations as a primary surgery without any history of microsurgical or endoscopic treatment. Four patients (22.2%) had previously undergone an operation to place a cystoperitoneal shunt before referral to our center, but the shunt was malfunctioning and the cyst was not showing any decrease in size. The old shunt was removed in the same operation after the endoscopic procedure in all 4 cases. Intraoperative findings were reported such as thickness and transparency of the cyst wall, fenestration of the cyst wall, whether it was technically easy or difficult, and any complications such as bleeding. The surgical procedure was considered successful if the fenestration was completed and enlarged, and good CSF pulsations were observed. Surgical failure meant that the surgical procedure could not be completed successfully.

**Outcome Assessment**

The patients were clinically assessed postoperatively to determine any improvement of preoperative symptoms or the occurrence of new neurological deficits or postoperative complications. Stabilization of head circumference in postoperative follow-up medical records for infants initially presenting with macrocrania was considered to be an improvement. A follow-up CT scan was obtained the next day to detect any postoperative intracystic bleeding or subdural effusion. Magnetic resonance imaging and/or CT was performed 3–6 months postoperatively and was compared with preoperative studies concerning any decrease in cyst size or improvement of hydrocephalus. Any recurrence or progression of symptoms was considered to be an indication for repeating MRI. Recurrence or progression of symptoms associated with an increase in cyst size and/or hydrocephalus on postoperative imaging was considered to be an indication for reoperation or revision surgery. If the fenestration was found to be closed at the second operation, a repeat cyst fenestration was performed. If the fenestration was found to be patent, a new shunt was placed. The follow-up period ranged from 12 to 78 months (mean 45.8 months). Data regarding improvement in symptomatology, radiological improvement of cyst size, incidence of complications, surgical failure, and incidence of recurrence were collected, summarized, and analyzed.

**Endoscopic Technique**

The endoscopic trajectory is designated according to the location of the cyst and the presence of an area of contiguity with the ventricular system and/or the subarachnoid cisterns.

For cysts extending anteriorly toward the lateral ventricle (10 cases, 55.6%), the patient is positioned supine and the head is minimally elevated. In most cases a skin incision and a standard midpupillary coronal bur hole are made. In infants, the entry point is located at the lateral margin of the anterior fontanel. The side of the incision was chosen according to the asymptomatic expansion of the cyst. A cruciate dural incision is performed and the frontal horn is cannulated with an operating sheath diameter of 6.5 mm, with an obturator inside. After withdrawal of the obturator, a rigid lens (wide-angle, straightforward, 0°) with a 2-mm-diameter, angled eyepiece, and working channel diameter of 3 mm is inserted. Anatomical landmarks are identified including the choroid plexus, thalamostriate, and septal veins. The cyst is observed to be bulg-
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ing into the lateral ventricle, and the cyst wall looks bluish in color. Fenestration of the cyst is performed sharply in a relatively avascular segment of the cyst wall using monopolar or bipolar electrocautery or microscissors. The fenestration is widened to prevent early reclosure, achieved sharply by widening the initial hole or connecting multiple holes using electrocautery. Devascularization of the cyst wall is performed by coagulating its vascular supply to prevent or slow its regrowth. Part of the cyst wall can be obtained for histopathological examination using punch forceps. Pulsed irrigation with lactated Ringer solution is used to prevent thermal injury and collapse of the ventricles. Any bleeding from the cyst wall usually stops with irrigation or coagulation. After opening and decompressing the arachnoid cyst, the endoscope is advanced through the foramen of Monro, into the third ventricle, and a standard endoscopic third ventriculostomy (ETV) is performed in cases showing secondary aqueductal stenosis due to compression induced by the cyst.

For cysts extending anteriorly toward the third ventricle (4 cases, 22.2%), the bur hole is placed more anteriorly in front of the coronal suture to obtain a trajectory that allows visualization of the posterior third ventricle. After the lateral ventricle is entered, the endoscope is advanced into the foramen of Monro. Once the third ventricle is entered, the cyst top wall (apical dome of the cyst) comes into view in the posterior aspect of the third ventricle. A ventriculocystostomy is then created in a standard fashion. After decompression of the cyst, the aqueduct, mammillary bodies, and floor of the third ventricle usually become visible. In cases showing hydrocephalus due to compression of the aqueduct by the cyst, further fenestration between the third ventricle and the interpeduncular cistern (ETV) can be safely performed through the same approach. After perforation of the floor of the third ventricle, flow of CSF through the fenestration is inspected.

Cysts showing significant asymmetrical lateral extension and/or not associated with marked hydrocephalus (4 cases, 22.2%) are approached through a parietal or occipital bur hole. The cyst was entered through the lateral ventricle in 2 cases and was directly punctured in 2 cases. The endoscope was then advanced inside the cyst, and its deep wall was successfully fenestrated to create a communication between the cyst and the subarachnoid space of the quadrigeminal cistern (cystocisternostomy). The endoscope is then advanced through the fenestration to ensure that all the layers are opened, to visualize structures in the basal cisterns, and to ensure the creation of an adequate communication.

At the end of the procedure, the cyst is vigorously irrigated to remove any blood clots that may promote fibrosis with closure of the fenestration, and to make sure that there is no air left inside the cyst cavity. The operating sheath is then withdrawn with the endoscope inside to look for active bleeding in the puncture canal. Because suturing of the dura is not feasible, the bur hole is packed with a gelatin sponge and the pericranium and galea are tightly sutured to prevent subgaleal CSF accumulation and fistula formation. The skin is closed carefully with interrupted sutures.

Results

Preoperative Characteristics

Of the 18 patients with QACs included in this study, 10 were males and 8 were females, with a male to female ratio of 1.3 to 1 (Table 1). The youngest patient was 3 months old, whereas the oldest patient was 8.5 years old (mean age 2.5 years). The cyst was extended to the right side in 11 cases and to the left side in 7 cases (right to left ratio = 1.6 to 1). Hydrocephalus-related symptoms were the most common symptoms, macrocrania was present in 11 patients (61.1%), and intracranial hypertension symptoms were present in 3 patients (16.7%). Developmental delay and gait ataxia were present in 2 patients (11.1%). Visual impairment, seizures, and Parinaud syndrome were each present in 1 patient (5.6%). The duration of symptoms ranged from 1 month to 1.3 years (mean 9.5 months). Four patients (22.2%) underwent previous operations at an outside institution to insert a cystoperitoneal shunt. Two patients (11.1%) had an associated subdural hematoma at presentation that was small in size and did not necessitate any surgical interference. There was a history of head trauma in 1 patient (5.6%).

Preoperative CT and MRI revealed a midline fluid-filled cavity originating in the quadrigeminal cistern with different shapes and degrees of expansion exerting mass effect on the cerebellum and brainstem, and extending upward in the supratentorial space in all cases (100%). Concomitant hydrocephalus was present in all cases, subdural hematoma in 2 cases (11.1%), and holoprosencephaly in 1 case (5.6%). In all cases there was an area of contiguity with the ventricular system and/or the subarachnoid cisterns.

Surgical Results

Surgical treatment included ventriculocisternostomy in 14 cases (lateral ventriculocisternostomy in 10 cases and third ventriculocisternostomy in 4 cases), ETV in 14 cases, ventriculocystocisternostomy in 2 cases, cystocisternostomy in 2 cases, and removal of a preexisting malfunctioning cystoperitoneal shunt in 4 cases. The choice of surgical procedure depended on the presence or absence of hydrocephalus and the presence of an adequate area of contiguity between the cyst and the lateral ventricle, third ventricle, or subarachnoid cisterns.

Localization of the cyst was technically easy in all cases (100%). Because the outer cyst wall was tough in most of the cases, fenestration was performed using sharp penetration by electrocautery or scissors. In only 2 cases (11.1%), the cyst was penetrated directly using the peel-away sheath and stylet of the endoscope. Fenestration of the outer cyst wall was performed successfully in all cases. After collapse of the cyst, the persistent redundant cyst wall was shrunken by electrocautery. Excision of the cyst wall was never attempted in any of the cases. Among the 4 cases in which the cyst was fenestrated with the subarachnoid cisterns, the inner cyst wall was avascular in all cases, translucent in 3 cases, and opaque in 1 case. The fenestration of the deep cyst wall was completed successfully in all 4 cases (100%). However, intraoperative bleeding occurred in 1 case (5.6%) during fenestration of the deep cyst.
Postoperative Outcomes

Clinical improvement after surgery was encountered in 15 (83.3%) of the 18 cases. The most likely symptoms to improve were those related to hydrocephalus. Head circumference stabilized or returned to normal rates in all 11 patients who presented with macrocrania. Intracranial hypertension symptoms completely disappeared in all 3 patients who presented with such symptoms. Both patients who had gait ataxia showed remarkable improvement. No more fits occurred in the patient who presented with seizures, even after cessation of all medications. Significant improvement occurred in the patient who had Parinaud syndrome. However, no improvement was observed in patients with developmental delay or visual impairment.

Postoperative MRI showed a decrease in cyst size in 14 patients (77.8%), whereas in the remaining 4 patients the cyst size was unchanged. The decrease in cyst size was more evident in patients in whom the cyst was fenestrated to the quadrigeminal cistern, and in infants below 2 years of age. Nevertheless, in none of the patients did the cyst totally collapse following the endoscopic procedure. Improvement of hydrocephalus occurred in 16 patients (88.9%).

During the mean follow-up period (45.8 months), a repeat endoscopic procedure was performed in 7 patients (all 4 patients with prior shunts and 3 of 14 patients without prior shunts). In the 3 patients without prior shunts, the initial procedure was lateral ventriculocystostomy in 2 patients and ventriculocystocisternostomy in 1 patient. In these 3 patients, the fenestration was found to be closed, and a repeat endoscopic cyst fenestration was performed in 2 patients, whereas in the remaining patient the fenestration was found to be patent and a new shunt was placed. In the 4 patients with prior shunts, the initial procedure was a lateral ventriculocystostomy in 2 patients and a third ventriculocystostomy in 2 patients. In these 4 patients, the fenestration was found to be closed and a repeat endoscopic cyst fenestration was performed; however, a new shunt was implanted later in all of these patients due to progression of symptoms and increase in cyst size.

Among 18 patients with QACs included in the present study, the need for a shunt was avoided in 13 patients (72.2%), whereas the remaining 5 patients (27.8%) were shunt dependent. It must be emphasized that 13 (92.9%) of 14 patients without prior shunts were able to remain shunt independent; however, none of the 4 patients with prior shunts was able to become shunt independent.

Discussion

Surgical Options

The indications for surgical treatment of arachnoid cysts are variable and should take into account the patient's age. Although operative management is indicated for symptomatic cases only, there is enthusiasm for surgical intervention in pediatric patients (especially those less than 2 years of age) demonstrating cyst growth or neural compression, even if asymptomatic, to allow for normal development and function of the adjacent brain. All patients included in the present study were children, and all were symptomatic.

Many surgical strategies have been developed in the management of arachnoid cysts, but the best surgical treatment remains controversial. Cystoperitoneal shunting is a technically easy procedure that leads to early obliteration of the cyst but is associated with a high shunt malfunction rate (as high as 40%). Craniotomy and cyst excision or fenestration is considered to be a more favorable option. However, it is an invasive approach that carries the risk of significant complications such as neurological deficits (hemiparesis or oculomotor palsy), meningitis, subdural hematomas, seizures, and even death. Moreover, craniotomy is not always effective, and the cysts can recur.

Endoscopic Treatment

The significant potential morbidity of microsurgical fenestration and the high incidence of recurrence of cystoperitoneal shunting prompted neurosurgeons to search for an alternative procedure. The endoscope is an ideal instrument for exploration of fluid-filled cavities, and the close proximity of QACs to the ventricular system and/or the basal cisterns makes such lesions appropriate for endoscopic treatment.

Different endoscopic approaches have been used in the management of QACs. An infratentorial supracerebellar route with a paramedian bur hole drilled 2 cm below the external occipital protuberance was used in 2 patients. A precoronal approach has also been used to perform a ventriculocystocisternostomy, where the anterior wall of the cyst is fenestrated from the third ventricle, whereas the posterior wall of the cyst is fenestrated at the superior surface of the cerebellum to provide communication between the cyst and the supracerebellar cistern, taking care to avoid the vein of Galen region. However, the preferred surgical procedure that can be used in most cases is ventriculocystostomy, and it can be performed either through the lateral or the third ventricles using a standard precoronal bur hole.

In a study by Erşahin and Kesikçi that included 17 patients with QACs, the cyst was bulging into the lateral ventricle and a wide ventriculocystostomy was performed in all patients. Endoscopic third ventriculostomy was performed in 13 patients. Two patients underwent aque ductal stent placement in addition to these procedures. In a study by Cinalli et al. that included 14 patients with QACs, ventriculocystostomy and ETV were performed in 6 patients, whereas ventriculocystostomy without ETV was performed in 8 patients. In the present study, lateral ventriculocystostomy was performed in 10 patients.
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(55.6%), third ventriculocisternostomy in 4 patients (22.2%), ETV in 14 patients (77.8%), ventriculocystocisternostomy in 2 patients (11.1%), and cystocisternostomy in 2 patients (11.1%).

Restoration of CSF Pathways

Quadrigeminal arachnoid cysts are almost invariably associated with hydrocephalus, which makes endoscopic treatment technically feasible because of the ability of the endoscope to work in large spaces. However, it makes the management of these cases more worrisome because of the need to treat both the expanding cyst and the hydrocephalus. It has been mentioned that a significant percentage of patients with QACs have associated obstructive triventricular dilation and signs of increased intracranial pressure. The hydrocephalus in these cases is obstructive in nature and is attributed to a secondary aqueductal stenosis due to the compression induced by the cyst. Consequently, one of the very important objectives of surgery is restoration of the CSF pathways to treat the associated hydrocephalus.

There is controversy concerning the need for performing ETV simultaneously with ventriculocisternostomy in the treatment of these cases. Many authors have stressed the importance of performing ETV together with simple opening of the cyst wall, because the CSF pathway is usually altered by extrinsic aqueductal stenosis arising from the long-standing high pressure exerted by the cyst, which may persist despite the cyst opening. Advocates for performing ETV believe that the CSF circulation is complex, and the turbulent circulation encountered postoperatively in the CSF flow dynamics on MRI at the cyst level, after simple fenestration of the cyst wall into the ventricle, may lead to secondary closure of the fenestration. If ETV is performed in addition to ventriculocisternostomy, there is direct flow from the third ventricle to the basal cisterns, limiting the turbulence and tendency of the stoma to close. In the author’s view, if ETV can be performed successfully, it obviates the need for further fenestration of the deep cyst wall toward the basal cisterns. However, in the current study, it is unknown whether the postoperative improvement of hydrocephalus is attributed to ETV or to reopening of the aqueduct of Sylvius following cyst decompression. It has been mentioned that hydrocephalus can persist in young children, especially infants or neonates, and this is probably due to immaturity of the subarachnoid space and deficiency of its absorptive capacity for CSF. Almost all the patients younger than 6 months of age included in the study of Erşahin and Kesikçi, who underwent both cyst fenestration and ETV, required a ventriculoperitoneal (VP) shunt postoperatively.

Morbidity and Mortality

In the study of Erşahin and Kesikçi including 17 cases of QACs operated on using endoscopy, 1 of the patients in whom the endoscopy procedure had not been successful died of shunt infection 7 months later. Postoperative subdural fluid collection developed in 3 patients. A subduraloperitoneal shunt was implanted in 2 patients, and the fluid collection was asymptomatic in the remaining patient. Cerebrospinal fluid fistula leak and meningitis developed in 1 patient in whom the endoscopic procedure was unsuccessful, and a VP shunt was subsequently needed. In the study of Cinalli et al. including 14 patients with QACs operated on by endoscopy, 1 patient developed a subdural hygroma that was treated with a subduraloperitoneal shunt, and 1 patient developed CSF leakage from the wound and required cystoperitoneal shunt insertion because of recurrent hydrocephalus.

In the present study, there were no deaths or permanent morbidities. Intraoperative bleeding occurred in 1 patient (5.6%); it was minor and stopped spontaneously after a few minutes following irrigation, without any postoperative sequelae. Subdural hygroma occurred in 3 patients (16.7%) and required the insertion of a subduraloperitoneal shunt in 2 patients. It is worth noting that in 1 of these 3 patients the cyst was punctured directly, and this confirms what has been stressed by some authors that introducing the endoscope inside the cyst cavity through the cyst wall directly increases the incidence of postoperative subdural effusion due to the escape of the cyst fluid into the subdural space. Consequently, we advise approaching the ventricular system first and then the cyst, to minimize the escape of CSF into the subdural space. Care should also be taken to avoid the release of CSF if the lateral ventricle is approached first, to prevent ventricular collapse with opening of the subdural space and occurrence of subdural hygroma.

Operative Outcome

In the study of Erşahin and Kesikçi, endoscopic intervention was successful in 10 (58.8%) of 17 patients with QACs. The cyst had either decreased in size or disappeared on follow-up MRI in all cases except for 1. In the study Cinalli et al., complete success was achieved in 7 (50%) of 14 cases of QACs operated on by endoscopy, defined as resolution of symptoms of intracranial hypertension and Parinaud sign, normalization of head circumference growth, and control of hydrocephalus and cyst size, with no further surgical procedure. Postoperative imaging showed a reduction in the size of the ventricles and cysts in all successfully treated cases. The more significant decrease in volume was observed in the first year after surgery.

In the present study, postoperative clinical improvement was encountered in 15 (83.3%) of 18 cases. The most likely symptoms to improve were hydrocephalus-related symptoms, gait ataxia, seizures, and Parinaud syndrome (100%). However, there was no improvement in developmental delay or visual impairment. Reduction in cyst size was noted on postoperative imaging in 14 cases (77.8%; Fig. 2). The reduction was more evident in patients who underwent operations involving fenestration of the cyst to the quadrigeminal cistern and in infants younger than 2 years of age. Improvement of hydrocephalus occurred in 16 cases (88.9%).

Failure and Recurrence

The long-term outcome of endoscopic treatment of
QACs is not well studied and the main reason for failure or recurrence with reclosure of the fenestration over time is not well known. There is no available information about a secondary endoscopic procedure in the treatment of recurrent cases. Many factors exist, such as the endoscopic procedure (ventriculocystostomy, ventriculocystocisternostomy, ETV), size of the fenestration, insertion of a cystocisternal catheter, resection of part of the cyst wall, presence of hydrocephalus, and the occurrence of intraoperative bleeding. Whether such factors have any influence over the long-term follow-up still needs to be addressed. There is a paucity of data in the literature concerning the incidence of cyst recurrence after endoscopic treatment of such cases. The available studies of endoscopic treatment of QACs are very few, and they include a small number of patients.

In the study of Erşahin and Kesikçi, including 17 patients with QACs operated on by endoscopy with a mean follow-up of 51.8 months, endoscopic intervention was successful in 10 patients (58.8%). Endoscopic procedures were successful in all patients older than 6 months of age. However, 7 (87.5%) of the 8 patients younger than 6 months old who had undergone both cyst fenestration and ETV needed a VP shunt. Treatment failure was also reported in 1 (11.1%) of 9 patients with QACs included in another study treated by cyst fenestration and ETV. In the present study, 7 of 18 patients (all 4 with prior shunts and 3 of 14 without prior shunts) required a repeat endoscopic procedure during the long-term follow-up (mean 45.8 months). At a second endoscopic procedure, the fenestration was found to be patent, and a new shunt was placed in 1 patient. In the remaining 6 patients the fenestration was found to be closed and a repeat endoscopic cyst fenestration was performed; however, all 4 patients who had prior shunts experienced progression of symptoms with an increase in cyst size and required a new shunt placement later. In conclusion, endoscopy was successful in obtaining shunt independency in 13 (92.9%) of 14 patients without prior shunts; nevertheless, none of the 4 patients with prior shunts was able to become shunt independent. It has been postulated that most of the patients who have preexisting shunts usually remain dependent on the device after endoscopic treatment, and this is attributed either to scarring from previous shunt-related surgeries or to loss of the ability of CSF absorption as a result of prolonged shunt use. Accordingly, endoscopic cyst fenestration is not recommended by the author in patients who have previously received a shunt.

**TABLE 1: Clinical details of 18 patients with QACs operated on using endoscopy**

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<th>Case No.</th>
<th>Age (mos), Sex</th>
<th>Clinical Presentation</th>
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<th>Endoscopic Procedure</th>
<th>Morbidity</th>
<th>Repeat Endoscopy</th>
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<td>SDH</td>
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* CC = cystocisternostomy; CPS = cystoperitoneal shunt; DDM = delayed developmental milestones; LVC = lateral ventriculocystostomy; SDH = subdural hygroma; VCC = ventriculocystocisternostomy; 3rd VC = third ventriculocystostomy.
Quadrigeminal arachnoid cysts

It has been reported that intraoperative bleeding during the endoscopic treatment of arachnoid cysts is one of the important factors predicting a bad outcome during long-term follow-up. It is noteworthy that intraoperative bleeding was encountered in 1 of 18 cases of QACs included in the current study. Interestingly, this patient required a second endoscopic procedure 3 years later, where the fenestration was found to be closed and a repeat endoscopic cyst fenestration was performed. Consequently, much effort should be given to avoid the occurrence of intraoperative bleeding.

There is no consensus on how wide cyst fenestration should be or whether the technique used to make the opening (Fogarty catheter, diathermy probe, laser, or scissors) has any bearing on the outcome. In the present study, fenestration of the cyst wall was performed sharply using monopolar or bipolar cautery or scissors, and it was enlarged sharply by using electrocautery. The author advises using a wide fenestration because of the high incidence of reclosure of small openings due to the low pressure differential across the cyst walls.

To prevent recurrence due to occlusion of the foramen of Monro or the sylvian aqueduct caused by a persistent redundant cyst wall, radical shrinkage of the dome of the cyst has been suggested. Other neurosurgeons advocate the placement of a fimbrial catheter through the fenestration into the adjacent ventricles or basal cisterns to prevent occlusion of the opening by collapse of the cyst and later scarring. However, implanting such a prosthesis carries the long-term risks of an internal shunt such as displacement of the shunt or its occlusion. The author advises shrinking of the cyst wall if it is redundant, to avoid occlusion of the foramen of Monro or the sylvian aqueduct with recurrence of hydrocephalus. Moreover, devascularization of the cyst wall by coagulating its vascular supply helps to prevent or retard cyst regrowth. However, a fimbrial catheter was not inserted in any of our cases, nor was there any attempt to excise the cyst membrane. Although it would be ideal to excise the cyst completely during the endoscopic procedure, it has not been previously reported in the literature. The ependyma and the cyst wall are usually fused together in a single layer, and a true cleavable arachnoid wall was never noted either during perioperative macroscopic observation or on microscopic analysis.

Conclusions

Arachnoid cysts of the quadrigeminal cistern and the associated hydrocephalus can be effectively treated by endoscopy. The procedure is simple, minimally invasive, and associated with low morbidity and mortality rates. If the endoscopic approach was used as the first line of treatment, it allowed the patient to be shunt independent in 92.9% in this study. The fact that all patients with previous shunt placements required repeat endoscopic procedures, and that none of these patients was able to become shunt-independent, makes it clear that endoscopic treatment should be considered the first choice in the management of these patients.

Disclosure

The author reports no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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