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Neuroendoscopic surgery of intracranial cysts in adults

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Abstract *Objects:* The purpose of this study was to describe the indications, surgical techniques and postoperative outcome of neuroendoscopic interventions in a heterogeneous group of intracranial cystic pathologies. *Patients and methods:* Between 1992 and 2003, 127 patients with symptomatic intracranial cysts and cystic tumours underwent neuroendoscopic treatment in our department. In 22 patients indication for surgery was colloid cysts, in 9 patients pineal cysts and in 3 patients cavum vergae cysts. Twelve arachnoid cysts, 10 cystic craniopharyngiomas, 2 Rathke's cleft cysts and 69 malignant cystic tumours were operated on. The patients' mean age was 45 years and their clinical presentations varied from typical signs of increased intracranial pressure to focal neurological deficits. *Results:* One hundred and twenty-seven patients with intracerebral cystic space-occupying lesions were operated on using

stereotactic frameless or frame-based endoscopic techniques. There was no operative mortality. The operative morbidity was 3.1% including 1 memory deficit due to fornix injury, 1 hemiparesis due to postoperative haematoma after lesion biopsy, 1 aseptic meningitis and 1 subdural fluid collection. *Conclusions:* Endoscopic interventions enable neurosurgeons to manage intracranial cystic lesions. Via the same approach, the obstructed CSF pathways may be restored and consequently the increased intracranial pressure diminishes. With the aid of stereotactic guidance or a neuronavigation system, access to the lesion can be gained rapidly and with high accuracy.

Keywords Arachnoid cyst · Brain tumour · Colloid cyst · Craniopharyngioma · Neuroendoscopy

Introduction

In the past few years, neuroendoscopic procedures have gained increasing significance and have been used more widely in handling intracranial lesions [29, 41, 45, 69]. Especially in the diagnosis and therapy of cystic intracranial or intracerebral pathologies, endoscopic techniques are extremely helpful [6, 38, 92]. This group of space-occupying lesions includes colloid cysts, arachnoid cysts, porencephalic cysts, pineal cysts, Rathke's cleft cysts, cystic craniopharyngiomas and malignant tumours

with cystic components. Considering operative morbidity and mortality of stereotactic microsurgical approaches to the lesions, endoscopic surgery provides the safer outcome due to direct inspection of the capsular vascularisation and consistence. Either definite or palliative treatment for the above-mentioned lesions could be achieved using neuroendoscopic techniques, depending on the histopathological diagnosis and aim of the therapeutic intervention (Fig. 1). Contrary to the benign parenchymal or intraventricular cysts, volume reduction of cystic anaplastic astrocytomas and glioblastomas as well as

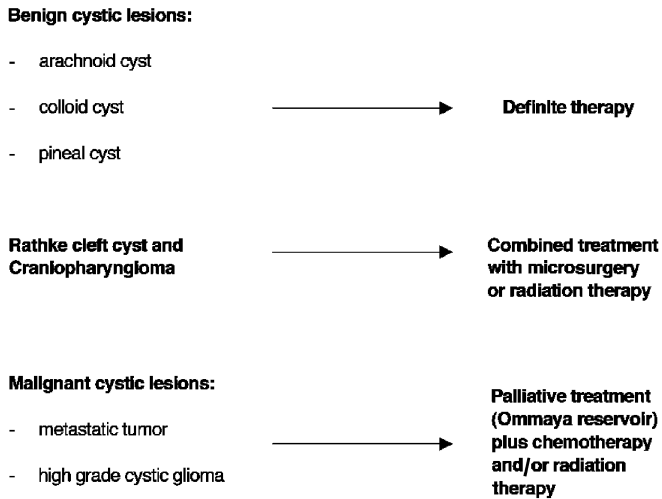


Fig. 1 Endoscopic interventions for intracranial cysts

metastases can be accomplished using endoscopic procedures in combination with the application of reservoir systems [38].

In the present study, we describe the indications, surgical techniques, and postoperative outcome of neuroendoscopic interventions in a heterogeneous group of cystic intracranial pathologies in adults.

Patients and methods

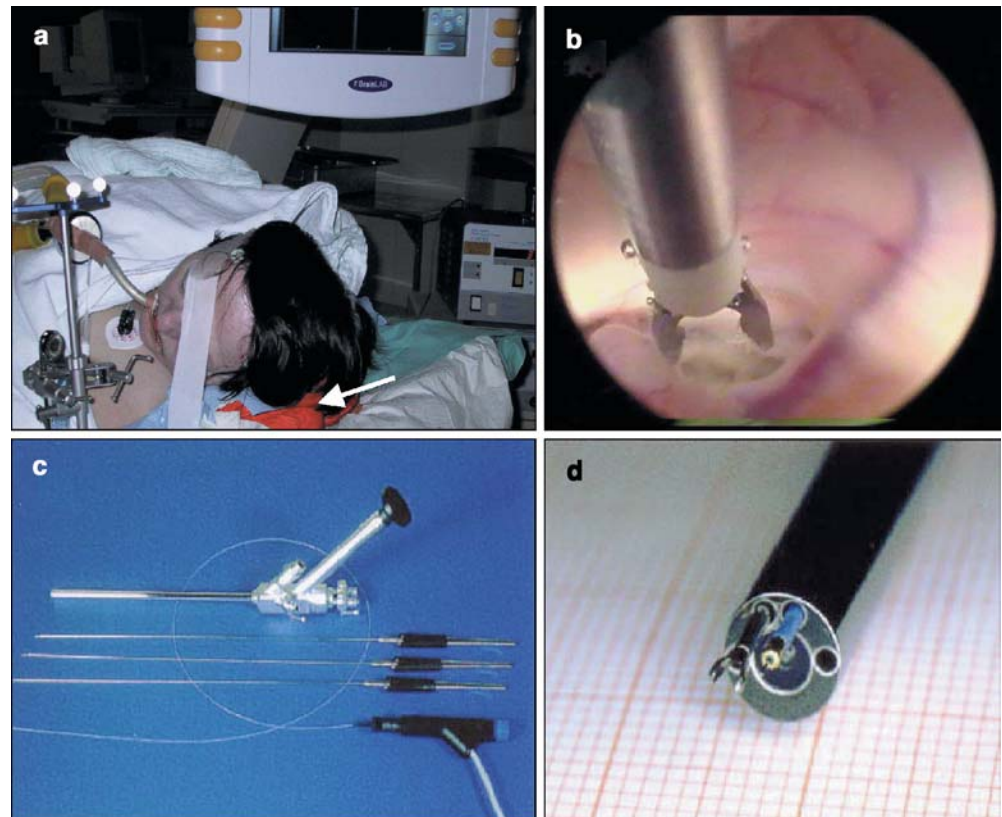
Patients

Between 1992 and 2003, 127 patients with symptomatic intracranial cysts and cystic tumours underwent neuroendoscopic treatment in our department. In 22 patients indication for surgery was colloid cysts, in 10 patients pineal cysts, and in 3 patients cavum vergae cysts. Twelve arachnoid cysts, 10 cystic craniopharyngiomas, 2 Rathke's cleft cysts and 69 malignant cystic tumours were operated on. The patients' mean age was 45 years (34–78 years), and their clinical presentations varied from typical signs of increased intracranial pressure to focal neurological deficits.

Instruments

Different rigid and flexible endoscopes for neuroendoscopic interventions are available. The specifications vary and one must choose according to the preoperative approach planning and intraoperative findings. While rigid endoscopes provide brilliant pictures and offer the possibility of looking around corners due to the various angled lenses, flexible neuroendoscopes have the advantage of steerability and manoeuvrability. Flexible fiberscopes make inspections and interventions of multifocal and multiseptated cystic lesions easier [40]. At present, rigid endoscopes with two working channels and different viewing angles enable surgeons to perform a two-handed resection technique. A comprehensive set of instruments for multiple-purpose procedures are standard in our department (Fig. 2). The stability of the endoscope during the operative procedure is necessary and can be provided by the Marburg Endoscopy Fixation and Guiding System [38]. The introduction of computer-assisted

Fig. 2 a The patient's head is affixed in a vacuum pillow (arrow). The patient's registration process can be performed without any technical problems and the navigation system has a high target accuracy. **b** Endoscopic view demonstrating biopsy of the tumour with the multipurpose bipolar forceps. **c** Working instruments (scissors, forceps, flexible bipolar coagulation and cutting electrode). **d** Rigid endoscope with two working channels enables a two-handed endoscopic technique to be performed



navigation into neurosurgical practice led us to utilise two different guidance systems: frame-based stereotactic and image-guided neuroendoscopic procedures. Details concerning these two stereotactic systems and their applications were described in our previous report [41].

Operative techniques

After induction of general anaesthesia, the patient's head is positioned and affixed either in the Mayfield head clamp or in a vacuum pillow depending on the location of the lesion and the navigation modalities (Fig. 2a) [85]. Current imaging data of the frameless system are obtained 1 day before the operation. The burr hole is localised and the trajectory to the lesions is planned. Following dural incision, the operating sheath containing the trocar is inserted with the aid of stereotactic or navigation guidance and is firmly fixed with the holding device [38]. Subsequently, the trocar is removed and the endoscope is introduced.

Neuroendoscopic technique in the treatment of intraventricular cysts

In intraventricular cystic lesions (colloid cyst, pineal cyst, cystic craniopharyngioma, Rathke's cleft cyst), orientation of the endoscope is achieved by identifying the anatomical structures (the foramen of Monro, septal vein and thalamostriate vein). Concomitantly, the position of the endoscope is verified with its position displayed on the navigation monitor. In accordance with the combined data from endoscopic image and navigation guidance, the endoscope is then readjusted towards the target lesion. After exposure of the lesion surface, the cyst membrane is opened using the micro-scissors or micro-catheters. Thin membranes may also be fenestrated by multipurpose bipolar forceps (Fig. 2b) [76]. The colloid cystic content may be aspirated either directly through the rigid endoscope's working channel or through an applied micro-catheter. If the content is too viscous (colloid cyst, cystic craniopharyngioma), it is aspirated by continuous rinsing. The remaining cyst capsule is vaporised using a radio-frequency probe. In colloid cyst patients or patients with craniopharyngioma, an external ventricular catheter is left in place after resection of the cyst wall in order to prevent aseptic ventriculitis that can be induced by the free-floating colloid material within the ventricular system. In the cases of pineal cysts, where the cyst is located in the posterior part of the third ventricle, a flexible endoscope is useful for approaching the lesion. The success of the intervention is confirmed intraoperatively by digital dynamic subtraction ventriculography in order to demonstrate the communication of the cystic lesion and ventricular system.

Neuroendoscopic technique in the treatment of arachnoid cysts and cystic neoplasms

Various rigid and flexible endoscopes are applied for cystostomy, cysto-ventriculostomy and cysto-cisterno-ventriculostomy. The operative procedure is performed according to the location of the lesion and the surrounding CSF space. Image guidance helps to localise the appropriate fenestration site and orientates the surgeon especially inside the arachnoid cyst. Micro-forceps and scissors are used to open and resect cystic membranes (Fig. 2c, d). In many cases, the application of electro-surgical device is necessary [39]. Coagulation probes with diameters of between 0.9 and 1.5 mm are available for both rigid and flexible endoscopes (Fig. 2c). The enlargement of stomas is performed with the aid of Fogarty balloon catheters. Digital dynamic subtraction cystography (cystoventriculography) is performed intraoperatively to display the communi-

cation of the fluid between the arachnoid cyst and the surrounding CSF compartments.

In the treatment of cystic neoplasms, localisation of the lesion is done by the navigation system and the rigid endoscope is introduced for biopsy. If necessary an Ommaya reservoir for repeated fluid aspiration is installed.

Results

From June 1992 to March 2003, 127 patients with intracerebral cystic space-occupying lesions were operated on using stereotactic frameless or frame-based endoscopic techniques. There was no operative mortality. The operative morbidity was 3.9% including 1 memory deficit due to fornix injury, 1 hemiparesis after biopsy, 1 aseptic meningitis and 1 subdural fluid collection. In this paper, we describe only some of the major lesion entities in detail.

Colloid cyst

In the early postoperative period, 22 patients had excellent outcomes, with immediately improved clinical signs. One patient who experienced intraoperative haemorrhage caused by laser application had reversible psychosis, memory deficit and third cranial palsy. Another patient remained shunt dependent caused by aseptic meningitis after the endoscopic procedure. In long-term follow-up examinations (1–10 years), 17 patients were symptom-free. One individual complained of intermittent headaches when facing stressful situations. Three other patients with preoperative memory deficits described gradual improvement. The patient who experienced intraoperative haemorrhage continued to have a slight short-term memory deficit. Follow-up imaging revealed an inconsistent decrease in ventricular size. Postoperative ciné MRI studies performed in 17 patients revealed the normal flow of CSF.

Pineal cyst

Nine cystic lesions of the pineal gland caused periodic headache and other unspecific symptoms (Fig. 3). Five preoperative neuroradiological examinations showed the cystic space-occupying lesion with enlarged ventricles. One individual revealed an obstructive hydrocephalus due to an aqueductal stenosis. All cysts were punctured and the content was aspirated using the flexible endoscope. The cystic membranous biopsies were pineal cysts in all patients. Adherent parts of the capsule were left in situ. The restoration of the CSF pathway was demonstrated intraoperatively by digital subtraction ventriculography (Fig. 3b) and postoperative MRI. All pineal cysts except

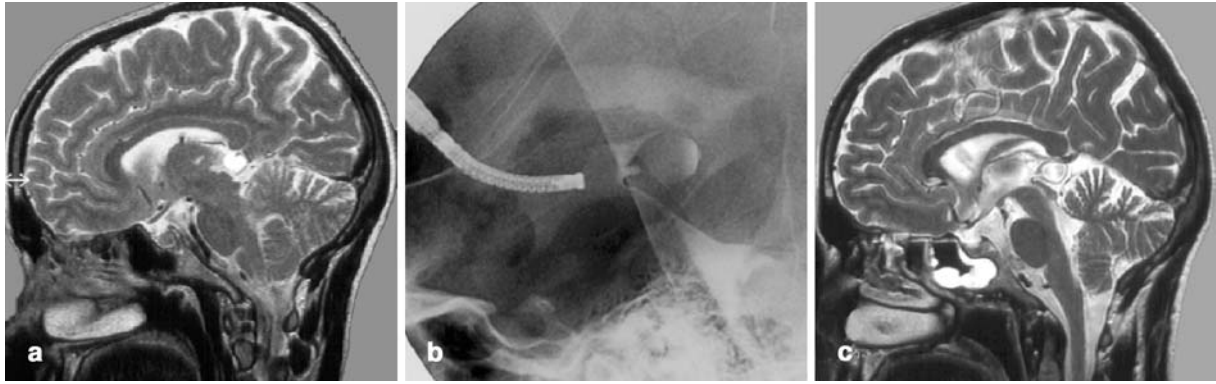


Fig. 3 **a** MRI demonstrating a space-occupying lesion in the pineal region, which causes compression of the proximal aqueduct of Sylvius. **b** Intraoperative ventriculography revealing the flexible endoscope in the posterior part of the third ventricle and the cyst cavity filled with contrast media as a proof of patent cysto-ven-

tricolostomy. **c** Postoperative T2-weighted MRI scan showing the flow-void phenomenon in the third ventricle and in the residual membrane of the pineal cyst. Note the decompressed cerebral aqueduct

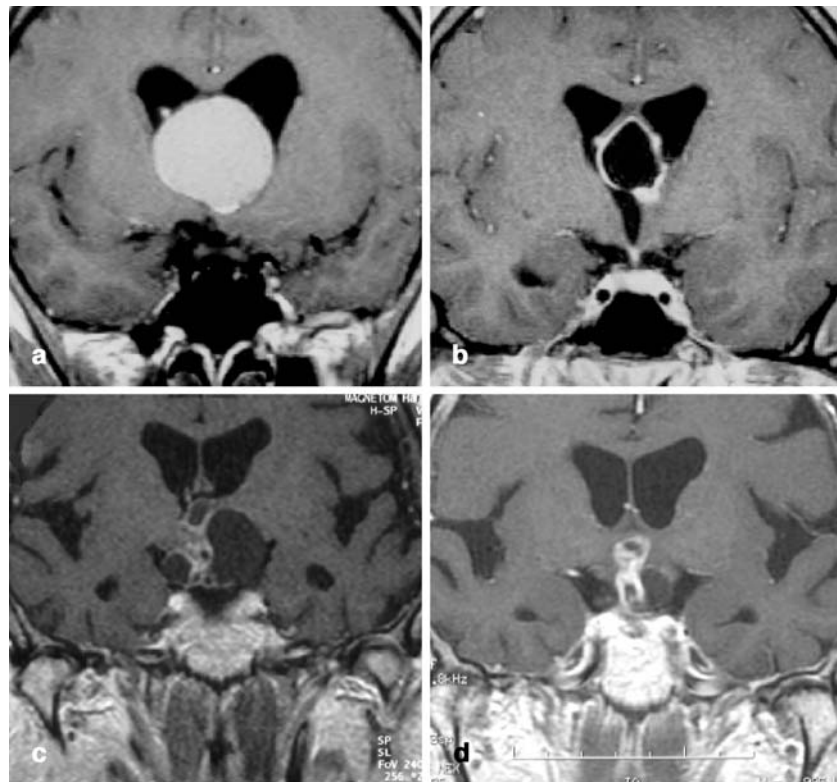


Fig. 4 **a** Contrast-enhanced coronal MRI shows a large cystic suprasellar lesion causing an occlusive hydrocephalus. Acute endoscopic intervention, with cyst evacuation and cystoventriculostomy, was performed due to deteriorated consciousness of the patient. Histopathological diagnosis revealed a craniopharyngioma. **b** Postoperative MRI examination reveals the totally evacuated cyst with the partial remnant of the tumour capsule. After patient's

condition improved, the membrane was resected via microsurgical intervention. **c** Preoperative T1-weighted MRI with contrast media demonstrates a cystic craniopharyngioma in a 74-year-old woman who presented with decreased visual acuity. **d** Postoperative T1-weighted MRI with contrast media reveals decreased size of cystic space; the remnant of the cystic wall was irradiated postoperatively

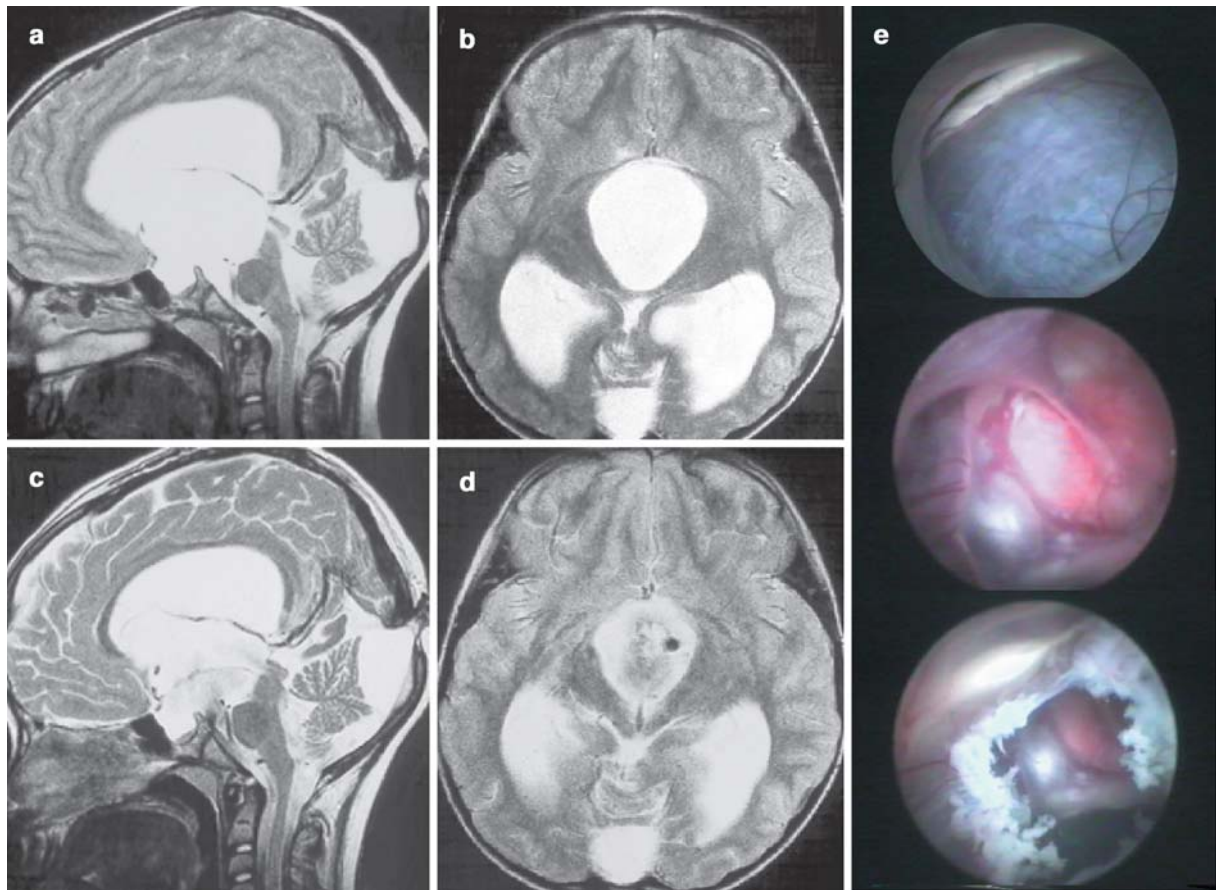


Fig. 5 a, b MRI scans show a suprasellar arachnoid cyst. c, d Patient underwent cysto-ventriculo-cisternostomy. Postoperative MRI studies reveal the collapsed cyst and a typical prepointine “flow-void” phenomenon. e *Upper*, the endoscopic view shows the

membrane of the arachnoid cyst. *Middle*, after endoscopic intervention the pituitary stalk and gland are seen. *Lower*, the membrane of Lilliequist, which forms the inferior wall of the cyst toward the prepointine cistern, is fenestrated (cysto-cisternostomy)

one were without recurrence. Follow-up periods ranged between a few months and 10 years.

Cystic craniopharyngioma and Rathke’s cleft cyst

After aspiration of the cystic content of the craniopharyngioma, the cyst wall is shrunk by laser beam or radio frequency application as much as possible. If parts of the capsule are adherent to parasellar structures, they are left in situ (Fig. 4). Eight patients are now without tumour recurrence, whereas in 2 patients, 9 and 12 months after the endoscopic intervention respectively, the remaining solid tumour portion was removed via a microsurgical technique.

Two patients who suffered from amenorrhoea and partial hypopituitarism secondary to the intrasellar Rathke’s cleft cysts recovered nearly completely after the endoscopic surgery.

Arachnoid cyst

In 12 patients with arachnoid cysts (9 hemispherical arachnoid cysts and 3 suprasellar arachnoid cysts; Fig. 5), symptoms were relieved in 8 patients and improved in 4 patients, whereas the size of the cyst decreased in all patients. Postoperative neuroradiological evaluation confirmed the success of the endoscopic procedures. There was one subdural fluid collection but no neurological deficit during the follow-up period between 1992 and 2003.

Cystic neoplasm

The goal of a palliative cure was achieved in the 65 cystic neoplasm patients by Ommaya placement (35 cases) or postoperative radiation therapy after endoscopic biopsy of the tumour (Fig. 6). Four patients with cystic tumour lesions were followed using microsurgical resection of the solid tumour and radiotherapy. One exceptional patient developed a cystic lesion after radiation therapy for the

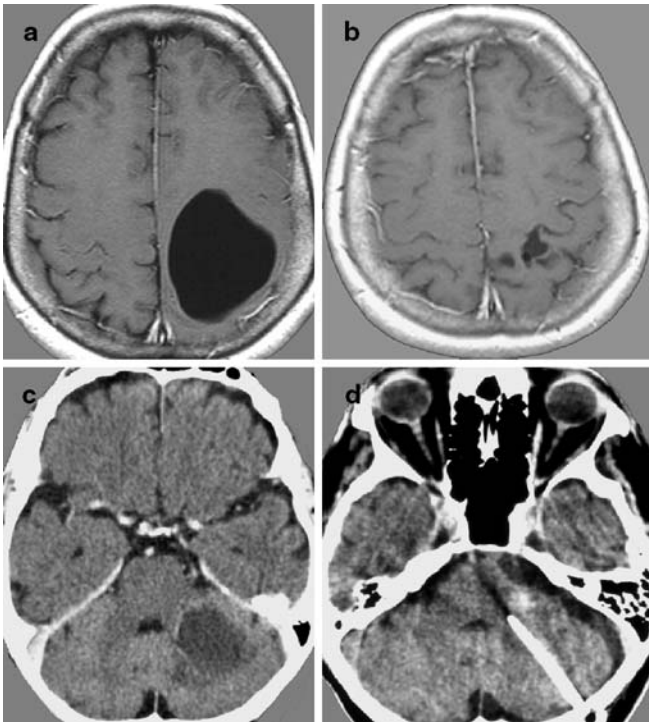


Fig. 6 **a, b** A 62-year-old female presented with speech disturbance and dizziness. **a** MRI reveals a left parieto-occipital arachnoid cyst. After endoscopic biopsy of the cyst wall, an Ommaya reservoir was placed. **b** The 6-month control postoperative CT scan revealed a cyst of less than 5 mm and the patient was free of symptoms. **c, d** Multiple metastatic tumour in an 80-year-old patient. **c** Preoperative CT scan reveals a right intracerebellar cystic tumour. **d** Postoperative CT examination demonstrates a collapse of the cyst and the catheter of an Ommaya reservoir placed endoscopically into the cystic lesion

intracranial metastatic tumour. The cyst was treated by placement of an Ommaya reservoir.

Discussion

Colloid cysts

In the past, either a transcortical–transventricular approach [4, 13, 14, 33] or a transcallosal approach [4, 5, 33, 42, 61] was deemed the gold standard in treatment of patients with colloid cysts. The former approach has often carried rather high operative morbidity and mortality rates [13, 65]. The latter, which may be an alternative nowadays, saves the cortex but can endanger bridging veins, the sinus and the pericallosal arteries, and may also traumatise the fornix. Gutierrez-Lara et al. [36] first performed freehand puncture and aspiration of a colloid cyst in 1975. Bosch et al. [9] performed the first stereotactic aspiration of a colloid cyst in 1978. However, for cysts with hard content, stereotactically guided aspi-

ration often failed [52] and had the potential to injure the fornix and may cause bleeding from ependymal veins [58]. Either an endoscopic or a microsurgical procedure was required after stereotactic aspiration [53]. The long-term results of the aspiration technique also revealed a high recurrence rate [60].

During the past decade, endoscopic treatment of colloid cysts has gained increasing importance [19, 20, 22, 23, 38, 41, 58, 72, 92]. In 1963, Guiot and co-workers [35] reported the use of ventriculostomy in a patient with a colloid cyst. In 1988, Auer et al. [6] operated on an intraventricular colloid cyst using a neodymium (yttrium-aluminium-garnet) laser. Many investigators underlined the effectiveness of neuroendoscopic approaches in the treatment of patients with colloid cysts [12, 22, 23, 58], even in long-term follow-up [1, 21, 41, 50]. Although Pollock and Huston [71] emphasised that colloid cysts have a relatively low risk of considerable growth, whether or not the cyst wall should be resected totally or some remnants left in place to reduce the surgical risk remains a matter of debate.

While the aim of endoscopic surgery for colloid cysts is the restoration of CSF blockage due to the mass at the foramina of Monro and the prevention of the recurrence, cyst evacuation as well as coagulation of the cyst wall seems to be a sufficiently effective alternative to microsurgical resection of the cyst [41]. Considering the postoperative evidence of our patients, which revealed no significant increase in the cyst size and an inconsistent decrease in ventricular size after long-term follow-up, we consider endoscopic surgery to be the treatment of choice in colloid cyst patients. However, the operating microscope should be kept ready to aid immediate microsurgical intervention in case of complications caused by the endoscopic procedure [29] or in a patient harbouring a calcified cyst when the content of the lesion cannot be aspirated [41].

Pineal cysts

Symptomatic pineal cysts are rare [27] and up to the present time, only 33 cases have been described [29, 38, 63, 66, 89]. A high degree of clinical suspicion is needed, because headaches may be the only feature. Although glial pineal cysts constitute a separate entity from pineal tumours and are common incidental findings on MRI [34, 59, 88], pineal parenchymal tumours may less frequently mimic the pineal cyst due to the cystic change of the tumour [15, 26, 67, 83].

The management of pineal cysts, as well as that of pineal tumours, has been the subject of debate in the last decade [10, 17, 43, 56]. Regarding pineal cysts, some authors advocate an open surgery technique [27, 64, 68], while others recommend stereotactic aspiration [56, 66, 75, 82]. Nowadays, the usage of endoscopy has been

proposed as an alternative treatment, either by flexible [38, 86] or rigid endoscopes [29, 63], and the mortality and morbidity rates are reduced to zero [38, 63]. We used both stereotaxy [38] and neuronavigation [3] in selecting the best route for the introduction of the endoscope. This technique was found to be helpful in approaching the posterior part of the third ventricle when the foramen of Monro was narrow [3]. We agree with Michelsen and co-workers [63] that once the ventricles are reached, the direct view offered by the endoscope is most reliable.

The main indication for the operative treatment of symptomatic pineal cysts in our series is headache and imaging demonstrating enlargement of the lateral ventricles. We performed the endoscopic fenestration of cystic lesions and obtained biopsy samples using the direct view. Thus, obstructive hydrocephalus (due to the occlusion of the cerebral aqueduct), which occurred in one patient, could be resolved and verified by intraoperative ventriculography. If the flow of circulating CSF cannot be guaranteed, we agree with Gaab and Schroeder and Di Chirico et al. that third ventriculostomy may be another option for solving the problem of increased intracranial pressure [24, 28].

Cystic craniopharyngiomas and Rathke's cleft cysts

Complete removal of a craniopharyngioma remains the treatment of first choice whenever possible. The main problem with craniopharyngioma surgery is recurrence. Even in patients who were operated on radically, the recurrence rate ranged between 7 and 24% [84, 90]. Total macroscopic removal, either using a transcranial or a transsphenoidal approach, cannot be achieved without morbidity and mortality [90]. Abdullah and Caemaert [2] and Hellwig et al. [38] have been reporting the endoscopic management of cystic craniopharyngiomas since 1995. For craniopharyngiomas that are cystic and located in or near the intraventricular area (Type D, E or F according to Yasargil et al.'s classification) [90], access via an endoscope is possible. Since craniopharyngiomas are usually subarachnoid tumours, they can be freed from the surrounding neurovascular structure [2].

Since 1995, we have applied endoscopic intervention in 10 patients, the cyst was punctured and evacuated to guarantee a sufficient inner decompression of the hypothalamus, the optic nerve and other surrounding sensitive structures. The cyst wall was vaporised and a partially solid part was taken for histological confirmation. It is our policy to treat cystic craniopharyngiomas by using endoscopic surgery in combination with microsurgery (Fig. 4a) or radiation therapy (Fig. 4b) if the patient has poor performance status. Particularly in cases of emergency such as optic nerve compression or deteriorated consciousness due to compression of the cystic craniopharyngioma, emergency endoscopic intervention may play an important

role (Fig. 4a). In cases of tumour recurrence, microsurgical resection [38], irradiation [91], gamma knife radiosurgery [7, 16], and even application of a cysto-ventricular shunt or an Ommaya reservoir [37] are recommended.

Rathke's pouch evaginates superiorly from the stomodeum of the 4-week-old human embryo. It is generally thought that persistence and enlargement of the residual cleft are responsible for the formation of Rathke's cleft cyst. Other explanations have suggested that the origin may be neuroepithelial cells [81], metaplastic anterior pituitary cells [74] or endodermal cells [44]. At autopsy, Shanklin found that a residual lumen between a portion of the anterior and posterior walls of the Rathke's pouch persisted in 22 out of 100 normal pituitary glands [80]. Such cysts of Rathke's cleft were recorded in 26% of routine autopsy series in four publications [8, 30, 62, 74]. Infrequently, these cysts enlarge enough to produce symptoms [40]; therefore, we would recommend endoscopic intervention in the symptomatic Rathke's cleft cyst as an alternative treatment to either transsphenoidal [25, 49] or transcranial surgery [51].

Many reports also documented that it was sometimes difficult to determine the absolute pathological diagnosis of Rathke's cyst due to the spectrum of histopathological characteristics of this cystic lesion [25, 77, 90]. This occurred in one of our patients and the neuropathologist had established the diagnosis as a Rathke's cleft cyst but a craniopharyngioma could not be ruled out.

Arachnoid cysts

Arachnoid cysts occur throughout the neuraxis, and generally, no communication is demonstrable between the cyst and the subarachnoid space, although occasionally during surgery an arachnoid cyst is observed being filled through an apparent one-way valve [47, 78]. Arachnoid cysts may be asymptomatic throughout life and rarely they may spontaneously regress [87]. There is an ongoing discussion whether or not an asymptomatic arachnoid cyst should be operated on to prevent a hindrance to normal brain development and function [18, 55]. However, if the indication for surgery is questionable, intracranial pressure (ICP) monitoring should be performed to prove ICP elevation or pathologic pressure waves [28, 40]. In addition, electrophysiological studies and proper psychological testing may reveal subclinical neurological deficits in some of these patients [46].

Upcoming surgical options for the management of symptomatic arachnoid cysts include the endoscopic resection of the cyst wall with opening of the membranes; consequently, the communication between the cystic lesion and the ventricular CSF pathway would be established [45, 79]. Other surgical treatments are shunting, craniotomy with fenestration or resection of the cyst [18, 55, 57]. Shunting procedure may have led to shunt revisions [18].

Whereas craniotomy with the resection of the cyst may be difficult and associated with major surgical complications, simple fenestration of arachnoid cysts also poses the risk of re-closure of the fenestration site [18, 31, 70, 73].

Due to the relatively high success rate of 71–81% in other endoscopic series [11, 45, 48, 70, 79], and also in our series when compared with the microsurgical series outcome [18, 32], the authors would recommend the minimally invasive endoscopic approach as the treatment of choice in patients with arachnoid cysts. We believe that it is advisable to plan the operative approach before the endoscopic fenestration procedure, either by stereotaxy [40] or neuronavigation system [3, 85]. Although conclusions regarding the long-term outcome after endoscopic intervention in our patients cannot be reached, it is reasonable to perform a large stoma of the fenestrated cyst (10–15 mm in diameter) in order to obtain a good outcome. In cases of suprasellar arachnoid cysts, after inspection of the parasellar region, it is absolutely necessary to open the membrane of Liliequist (cysto-cisternostomy), which forms the inferior wall of the cyst towards the prepontine cistern, by using the basilar artery as a landmark (Fig. 5).

Cystic neoplasms

Endoscopic interventions for intracranial cystic neoplasms (anaplastic astrocytomas, glioblastomas, metastases) are performed less invasively to diminish the increased intracranial pressure and to establish the histopathological diagnosis. These cysts may also develop after radiation of postoperative brain metastasis or malignant glioma [54, 85]. Placement of an Ommaya reservoir can be an alternative treatment for this group of

patients in cases of impaired performance status. The main goal of the treatment is to maintain the patient's quality of life for the remaining small period. The decision to carry out a secondary microsurgical tumour resection should be made with consideration of the patient's general status.

Conclusion

Endoscopic intervention for cystic intracranial lesions enables the resection of the cyst wall and optimal tissue examination. Via the same approach, the obstructed CSF pathways may be restored and, consequently, diminish the increased intracranial pressure. With the aid of stereotactic guidance or a neuronavigation system, access to the lesion can be gained rapidly and with high accuracy.

A definite therapy is the aim of endoscopic interventions for benign intracerebral cystic lesions (colloid cysts, pineal cysts and arachnoid cysts). It is our policy to treat cystic craniopharyngiomas using endoscopic surgery in combination with microsurgery or radiation therapy if the patient has poor performance status. Particularly in emergency cases such as optic nerve compression or deteriorated consciousness due to compression caused by a cystic craniopharyngioma, emergency endoscopic intervention may play an important role. Endoscopic interventions for intracranial cystic neoplasms are palliative and are performed less invasively to diminish the increased intracranial pressure and to establish histopathological diagnosis. Combined treatments, i.e. chemotherapy, irradiation and placement of an Ommaya reservoir, are alternative treatments for this group of patients. The main goal of the treatment for cystic neoplasms is to maintain patient's quality of life.

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