Review Article

Why neuroendoscopy is not for all supratentorial intracranial arachnoid cysts in children

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Cerebral neuroendoscopy is a minimally invasive approach that reduces brain exposure, retraction and mobilization of neural tissues and neurovascular structures and the treatment of intracranial arachnoid cysts by endoscopy has been widely used. Selection of the patients who are most likely to benefit remains challenging in certain cases. The purpose of this article is to raise questions and observations regarding its indication and failure in pediatric patients with suprasellar, and middle fossa arachnoid cysts. We searched English-language articles published in the last 20 years and found evidence that Neuroendoscopy emerged as an alternative to the treatment of this pathology and has its definitive role as a safe, less morbid strategy in these supratentorial pediatric arachnoid cysts and must be added to the therapeutic protocols respecting the best indication.

Keywords: Pediatric arachnoid cysts; Supratentorial arachnoid cysts; Neuroendoscopy; Middle fossa arachnoid cysts; Suprasellar arachnoid cysts

INTRODUCTION

The application of cerebral neuroendoscopy, since Walter Dandy, in choroid plexus coagulation for congenital hydrocephalus (1), uses concepts of a minimally invasive approach, minimal mobilization of neural tissues and neurovascular structures, associated to a pursuit for lower surgical morbidity, shorter length of hospital stay and minimal blood loss (2), representing common aspects considered in pediatric neurosurgery. However, it is important that the selection of the patient is adequate considering that, in neuroendoscopy, it is related with the feasibility and success of the procedure (3, 4).

Treatment of intracranial arachnoid cysts by endoscopy has been the current choice for those located in deep-seated regions, such as quadrigeminal (5-9) and suprasellar cysts(10,11); and is the first option for cysts of the temporal middle fossa and posterior fossa, with techniques, variations and results widely available in the specialized literature.

Despite the undeniable evolution of neuroendoscopy techniques in the last 20 years, the purpose of this article is to raise questions and observations regarding its failure in pediatric patients with suprasellar and middle fossa arachnoid cysts, which correspond to the largest portion of arachnoid cysts of the skull, based on extensive literature review.

METHOD

English-language articles published in MEDLINE, PubMed, and Cochrane from 2000 to June 2022 searched for the terms “cranial arachnoid cysts”, “middle fossa arachnoid cysts”, “suprasellar cysts”, “suprasellar arachnoid cysts”, “arachnoid cysts”, “cystoperitoneal shunt”, “neuroendoscopic fenestration”, “microsurgical fenestration”. The “related articles” and “cited in other articles” function was used to obtain additional relevant articles. The age range of participants was 0 to 18 years. Case series, case reports and systematic reviews without information on complications, failures, morbidity and mortality were excluded. Evaluation of surgical outcomes for cortical and interhemispheric arachnoid cysts was not used because there is no consensus on the best technique for its treatment in the researched databases. Articles on secondary arachnoid cysts (due to infection, trauma, surgery, or intracranial hemorrhage) were also not included.

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RESULTS

Middle fossa arachnoid cysts

There are some classifications for arachnoid cysts of the temporal fossa: primary or secondary (non-congenital), whether or not they communicate with the circulation in the basal cisterns (12) or according to their size in relation to the middle cranial fossa – Galassi classification being the most used to define criteria for surgical decision, prognosis and scientific publications: type 1 (limited to the anterior portion of the middle fossa), type 2 (triangular or quadrilateral shape, which occupies the anterior and central parts of the middle fossa extending along the the sylvian fissure) and type 3 (larger, oval or rounded, occupying the middle fossa in almost all its extension and towards the cerebral hemispheres) (15).

Successful outcome for cysts in this region is related to: complete and wide fenestration, good CSF pulsatility and directly visualized basilar artery (12-14) (FIGURE 1). Choice of the ideal technique can reduce early risks, with a greater chance of cure, and lower possibility of recurrence(12, 15-19). Three cardinal aspects take part in the decision making:

1) Need for wide fenestration: there are three membranes considered to be of paramount importance for fenestration in middle fossa cysts: optic-carotid, oculo-carotid and oculo-tentorial (FIGURE 2); the recurrence rate is higher in those with a cystocisternostomy, regardless of which of the three is chosen. Wide opening with adequate visualization of structures beyond these was associated with 100% success rate of the procedure; for some authors, communication with the oculocarotid and oculotentorial spaces (19) showed as well, total effectiveness, with success criteria determined by the improvement of symptoms and no recurrence or reduction of cystic dimensions (12,19).

2)Risk of subdural effusions: : Galassi 3 arachnoid cysts in children younger than 2 years (16, 17) are more likely to have this late complication. The pathophysiology of subdural effusions or hydrocephalus remains unclear. In patients with large middle fossa cysts, especially those younger than 2 years of age, the rapid drop in intracystic pressure after surgical fenestration would cause, in addition to an increase in global CSF production, a regional change with closure of the communication between the cyst and the basal cisterns, in a region already with influx of cystic material into the subdural space after cyst opening, resulting in fluid accumulation and occurrence of subdural effusion. Combination of this phenomenon with an immature mechanism of absorption by the arachnoid villi in children of this age group would meet the necessary conditions for the appearance of subdural effusion and/or hydrocephalus (18,19). The possibility of shunting can be considered early in this population, even in microsurgical fenestrations.

3) Risk of venous hemorrhages and cranial nerve injuries (12,14): thicker cyst walls in the region adjacent to the basal cisterns visualized on MRI of the skull are associated with the presence of several successive membranes, greater opacity and less transparency of the related neurovascular structures, with an increased risk of venous bleeding and reocclusion of the fenestration. The proximity of the cyst to the cisterns must be evaluated and measured in pre-surgical images. Maneuvers necessary to create multiple fenestrations in addition to the risk of hemorrhages can damage the optic and oculomotor nerves. In these cases, the Keyhole microsurgical approach may generate superior results and fewer early complications, even considering the main appeal of neuroendoscopy and its shorter hospital stay and lower surgical morbidity (21).

Suprasellar arachnoid cysts

Suprasellar cysts, despite the name, are characterized by being originated from the prepontine region, displacing the optic chiasm anteriorly and the third ventricle superiorly. They are the most frequently diagnosed arachnoid cysts in the prenatal period (11,22). They develop as cystic dilatation of the interpeduncular cistern or of the intra-arachnoid region of Liliquist´s diencephalic membrane(22). Such observed implications allow a targeted surgical strategy.

After the 70's, cystoperitoneal shunt was the method of choice when compared to open microsurgery, due to the high morbidity of procedures with craniotomy (23). From the 2000s onwards, shared experiences of diverse neurosurgical teams demonstrate no doubt about the choice of the endoscopic approach (24-25), but leaving the question of which corridor will be created: cystoventricular or cystoventriculocisternal . In suprasellar region cysts, the endoscopic success criteria are three: shrinkage of the cyst walls, improvement of pontine deformation and horizontalization of the mammillary bodies and optic tract (6).

The combination of endoscopic success criteria, choosing the ideal patient and anatomical characteristics are the basis for achieve better results and lower morbidity:

1)Current evidence suggests that asymptomatic cysts in children under 4 years of age should be monitored for growth (26). Those diagnosed in the prenatal period, however, disappear or stabilize without symptoms during follow-up in a significant proportion of cases (11) Although, in adults, the most common symptoms are related to increased intracranial pressure, in children the most frequent clinical presentation is macrocephaly associated with neuromotor deficit, hormonal deficiency and ocular motor nerve palsy (24). It is not expected, however, that

hormonal deficiency and ocular motor nerve palsy improve postoperatively.

2)There is no difference in the reduction of cyst dimensions in VC or VCC; the difference lies in the higher rate of recurrence of the former (27). Better effectiveness does not exempt VCC from a significant rate of complications: transient VI nerve palsy, hormonal deficit and cerebral salt wasting syndrome (CSW). Distorted anatomy, basilar artery adjacent to the cyst on pre-surgical MRI, small cysts for navigation and low cyst floor in the prepontine cistern are criteria for choosing the VC technique – very small or premature children are relative contraindications (28).

3)Suprasellar cysts without hydrocephalus can be treated with neuroendoscopy and neuronavigation technique, expanding the foramen of Monro, identifying a valvular mechanism at the base of the cistern and enlarging it, being the preferred surgical treatment compared to creating other, narrower spaces (29)

DISCUSSION

Congenital arachnoid cysts are collections that occur in 2.6% of children; most of them in the supratentorial compartment (90%). Developing from abnormal duplication or partitioning of the arachnoid membrane or incomplete separation of the endomeninges, part of the perimedullary meshwork, in the early embryonic period (30,31), primary arachnoid cysts are associated with other CNS abnormalities such as partial or complete agenesis of brain lobes. The growth mechanism, which involves active secretion from the cyst wall, valve mechanisms that cause inflow of CSF into its interior, either by arterial pulsation or by obstruction of a retrograde flow, makes the standardization of evaluation criteria an even greater challenge, since different locations involve different mechanisms (32). In this context, Di Rocco and Tamburrini raised questions that remain valid today about why we operate on middle fossa cysts. Surgical indications are not universal and even the classic ones – headache, epilepsy, significant delay in neuromotor milestones, are not always related to the preoperative dimensions of the cyst, intracranial pressure or post-surgical evolution. For the authors in question and for us, the choice of which patients to treat and how to treat often requires not only technical knowledge, but also depends on the surgeon's experience and, therefore, unrelated to the choice of the best surgical strategy in middle fossa CAs (32,33). The assessment of cerebral perfusion in the region could be a strategy to elucidate this issue (35).

The impossibility of clinically prospective randomized trials and different pathophysiology in different locations cause divergences on the choice of technique for approaching middle fossa, cortical and interhemispheric and arachnoid cysts. Opinions regarding the best alternative continue to be conflicting, the latter presenting better results achieved with open microsurgery (29, 36-42). However, neither pathophysiological aspects nor age of the patients are described as limiting factors for the surgical options identified, with pros and cons present in all of them (43-45).

The evolution of microsurgical and endoscopic techniques in the last 30 years resulted in a complete shift, transitioning from the shunt as the first choice (46) to microsurgical fenestration (47); Currently, the role of endoscopy in arachnoid cysts deeply located in the suprasellar and quadrigeminal cisterns is not discussed, nor by the authors of this study. In middle fossa cysts, although more common, the discussions continue: in 2008, in the world multicenter Survey of middle fossa cysts, the preference was the microsurgical technique in 2/3 of the participants, however, Chen, 2016, published a meta-analysis reporting that the endoscopic approach was considered the first option because of the lower risk of early complications, not because of the effectiveness that was similar among the 03 main techniques: shunt, microsurgical fenestration and endoscopic (47). The most plausible justification to us is that since the arachnoid cysts of the middle fossa in children are treated as a benign condition, avoiding early complications associated with major surgeries, such as neurological deficits, subdural hematomas or hypertensive hygromas is of paramount importance in this group. When comparing the three main methods, the results were similar in quality of life after 05 years, but with a statistically significant difference in the overall success rate (greater efficacy + lower risk of early complications + lower risk of late complications) between endoscopy and shunt, which had the highest rate of late complications (40%) and shunt dependence in 42% of cases. Although the reduction in the size of the cysts was greater in patients undergoing shunt and microsurgery, the lower rate of early complications in endoscopic procedures in the treatment of temporal fossa cysts resulted in preference among the authors evaluated (12,14,47) .

The most recent meta-analysis on the subject raises even more questions about the pre-surgical evaluation, the technique chosen and the surgical results (24).

In cases of patients with familial arachnoid cysts, the postoperative course has been similar to that of sporadic cysts, with no need to choose a technique based on specific genetic alterations. (48-52).

On the other hand, there is no discussion about endoscopy as the treatment of choice for suprasellar cysts (11,28,53). The techniques described involve the creation of a cystoventricular or a deeper, cystoventriculocisternal pathway. However, the search for predictors of success and choice of the best technique are still under discussion. There is no significant difference in reductions in cystic dimensions despite the fact that cystoventriculostomy presents a higher

rate of recurrence compared with CCV (27-29). Explanations for the higher failure rate of the VC would be: formation of a sealing membrane in the superior fenestration after the collapse of the cyst, cystic fluid exiting through the inferior cisternal route in the VCC, presence of preoperative aqueduct stenosis that makes the relief of the apical portion of the cyst insufficient, with recurrence of hydrocephalus (53,54,58). Based on the analysis of 35 cysts operated on in their service, the Paris Group proposed a simple classification of suprasellar cysts based on prognosis and treatment modality (21). They observed that all cysts in this region displaced the optic chiasm anteriorly and the third ventricle superiorly and expanded from the chiasmatic or interpeduncular cisterns. According to their morphology and associated characteristics, it was possible to separate them into 03 subgroups (Table 1)

Table 1 - Subgroups of Arachnoid cysts

Types	Features	Extension	Diagnosis	Management
SSC type 1 (43%)	Blockage of both foramen of Monro and associated ventricular dilatation	Inferior displacement and duplication of the diencephalic leaflet of the Liliquist membrane	Hydrocephalus (100% of cases)	Neurosurgical management with brevity
SSC type 2 (31,5%)	With prepontine expansion only	Ascension of the diencephalic leaflet of the Liliquist membrane that remains anterior with consequent dilatation of the interpeduncular or prepontine cistern	Diagnosis often antenatal	Can be treated conservatively if they remain stable
SSC type 3 (25,5%)	Temporopolar or sylvian lateral expansion	Displacement of the basilar artery caudally to the cyst	More associated with macrocrania without hydrocephalus	Best surgical prognosis among the three

CONCLUSION

Among the various techniques available for the management of properly indicated arachnoid cysts, the differences between them in terms of symptom resolution are not clearly apparent. The choice of method of treatment, thus, depends on the surgeon's experience and management of short- and long-term complications. Knowledge of these complications should be considered to the decision-making process of the best type of treatment. Neuroendoscopy emerged as an alternative to the treatment of this pathology as a safe, less morbid strategy in supratentorial pediatric arachnoid cysts, however, the best indication must be respected, in order to reduce complications and enhance good results.

DISCLOSURES

Ethical approval

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Committee

Consent to participate

The patient gave consent to use his information and images for research proposes.

Consent for publication

The patient gave consent to use his information and images for publication.

Conflict of interest

The authors declare no conflicts of interest with respect to the content, authorship, and/or publication of this article.

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