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REVIEW

Surgical indications in pediatric arachnoid cysts

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Abstract

Introduction Arachnoid cysts are developmental lesions consisting of CSF collections within the subarachnoid space. There are many theories and hypotheses about their pathogenesis and histopathology and this may also explain the diversities seen in clinical behaviors of these cysts, their natural history and consequently their management where there is a great controversy about selecting patients for surgical intervention. The most common location in pediatrics is the Sylvian or middle cranial fossa and this made it gain more concern and greater debate about its management where its diagnosis is often accidently or associated with nonspecific symptoms.

Aim Our aim in this article was to review the main surgical indications for pediatric arachnoid cysts in the literature.

Conclusion We concluded that the decision for surgical intervention for pediatric arachnoid cysts is not a simple one and highly debatable and should be taken cautiously especially with sylvian arachnoid cysts that may reach a large size without symptoms. However, there is a consensus that the occurrence of symptoms definitely correlated to the presence of these cysts or their rupture with consequent subdural hematoma or hygroma are indications for surgical intervention. Large cysts in locations compressing CSF pathways causing hydrocephalus are also candidates for surgical fenestration. The surgical gain from prophylactic surgery is questionable particularly when asymptomatic.

Keywords Arachnoid cysts · Intracystic hemorrhage · Fenestration · Sylvian fissure · Surgical indications

Introduction

Arachnoid cysts are developmental lesions consisting of CSF collections within the subarachnoid space. Many theories explained their formation as splitting of the arachnoid membrane during its formation [1, 2] or secondary to trauma [3, 4]. Genetic mechanisms for their development were also suggested [5–8]. Enlargement of these cysts, when it happens, was proposed to occur by different mechanisms as one-way valve mechanism for fluid entrance, osmosis, and active secretion by cells lining the cyst lumen [9–11]. The recent histopathological studies documented different wall morphology of these cysts that varies between arachnoid-like tissue, fibrous connective tissue, and mixture of various elements as ciliated epithelium, glial, and neuronal components [12], and this goes in hands with the previous reports that reported cysts wall resembling arachnoid tissue or containing other elements as choroid plexus or respiratory-like epithelium [13–16]. These findings made the rising hypothesis that cyst morphology may be a relevant factor in cyst growth and may have an effect on cyst fluid composition and turnover [12, 17]. All these different facts about pathogenesis and histopathology may be the basis of the diversities seen in clinical behaviors of these cysts, their natural history, and consequently their management where there is a great controversy about selecting patients for surgical intervention [18, 19]. Because the most frequent site for arachnoid cysts is the sylvian fissure, those arachnoid cysts attain a great proportion of concern and debate among neurosurgeons not only in selecting the optimal surgical technique [20–22] but also in selecting patients with actual need for surgery [23]. Sylvian arachnoid cysts were classified according to their size into 3 grade by Galassi et al. [24]; however, it is not correlated to clinical presentations of these cysts that are mostly present by non-specific symptoms and signs, or they are discovered accidently. Our aim in this article was to review the main surgical indications for pediatric arachnoid cysts in the literature.

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Symptomatic arachnoid cysts and their locations

There is no debate that surgery is indicated in cases of symptomatic arachnoid cysts where symptoms are generally due to focal pressure effects on surrounding neural structures or globally elevated intracranial pressure by the cyst itself or secondary to associated hydrocephalus [25, 26]. Although the location of the arachnoid cyst was not found as a significant predictor for surgery by some [27], arachnoid cysts in cerebellopontine angle, suprasellar region, ambient, and quadrigeminal cisterns were found to be correlated more with the presenting symptoms due to compression on surrounding neurovascular structures or compressing a narrow CSF pathway or foramina causing hydrocephalus, opposite to those located in middle cranial fossa where correlation to symptoms may be more challenging [28] although this is the most common location in pediatrics [29].

The clinical situation where the existing neurological symptoms and signs may be poorly correlated to the presence of arachnoid cyst is not uncommon, and this makes surgical outcomes unsatisfactory as was clearly evident in one study where surgical gain was obtained only in 28% of patients and the improvement rate in the cases that showed poor correlations between the presence of arachnoid cysts and clinical symptoms was very low [30]. The decision for surgical intervention must consider the expected surgical outcome, the fact that surgery is not guaranteed to relieve symptoms [25, 31–36], and the non-negligible incidence of complications associated with fenestration procedures [30, 37–42].

Quadrigeminal arachnoid cysts are indicated for surgical fenestrations when associated with macrocrania, headaches, vomiting, lethargy, papilledema, and impairment of upward gaze and other ocular disorders [43] which are caused mainly by hydrocephalus associating arachnoid cysts in this location as they compress or distort the cerebral aqueduct at an early stage.

Suprasellar arachnoid cysts should be managed by surgical fenestration when they are presenting with signs of increased intracranial tension, affection of the visual field or acuity, motor deficits, or head nodding [44, 45]. The occurrence of isolated endocrine disorders secondary to arachnoid cysts in this location should not be considered as an indication for surgery as many authors had observed the persistence of endocrine dysfunction despite successful surgeries [45, 46].

The decision to operate on a middle cranial fossa arachnoid cyst (sylvian fissure arachnoid cyst) is the most debatable one and should be taken cautiously to select the true symptomatic arachnoid cyst in this location. Surgical patients with cysts in this location are operated upon mostly for either headache or epilepsy [23]. However, the correlation between these symptoms and the presence of the cyst remains questionable in most cases even with workup studies done by some investigators to identify surgical patients as prolonged intracranial pressure monitoring [23, 47] where results were not significant in gray zone cases or as studies on single photon emission computerized tomography scans that still has limited preliminary data [22, 48]. The same is true regarding epilepsy workup with EEG where results showed either poor correlation between seizures and cyst location, the presence of contralateral abnormalities, and about one-fourth of cases with epilepsy showed developmental cortical anomalies far from the cyst in video EEG studies [18, 49]. Some authors recommend treating sylvian fissure cysts only when associated with hydrocephalus and papilledema; otherwise, observation is recommended even with large cysts (Galassi type III) [50].

Rupture of arachnoid cysts

Rupture of the arachnoid cyst is one of the main indications for surgical intervention [27, 51, 52]. It may be traumatic, even after minor head trauma or may be spontaneous [51, 53]. Rupture of the arachnoid cyst was reported to be associated with intracystic hemorrhage, subdural hematoma either chronic or acute, and subdural hygroma [52, 54]. About 80–95% of cases in the literature had presented with headache, and nearly 40 to 50% had nausea and vomiting, and these symptoms are supposed, in most of cases, to be related to meningeal irritation rather than increased intracranial pressure which may be the case as well. Focal neurological deficits are relatively rare but possible [51]. The source of bleeding is hypothesized to be from the unsupported surrounding bridging veins traversing the arachnoid cyst wall that has less compliance than the normal brain [55]. Microsurgical fenestration of the cyst wall into the skull base cisterns in addition to evacuation of the associated hematoma or hygroma had a good outcome in the literature as regarding decompression of the brain and elimination of the risk of rupture recurrence [51], and it should be considered the choice of management as long as it is safe and feasible, keeping evacuation of the hematoma only in cases of high risk as very young age or too thick arachnoid basal cisterns although some prefer to limit surgical intervention to dealing with hemorrhage alone especially when those cases of arachnoid cysts were symptoms free before being ruptured. Others prefer to limit intervention to hematoma evacuation, and if symptoms persist, additional arachnoid cyst surgery should be done [56, 57]. Conservative management for ruptured arachnoid cyst was adopted in some reports with good clinical outcome, but long-term follow-up was lacking [58–60].

Size and cyst progression

Using the cyst size at diagnosis may be of value in making surgical decisions as suggested by some investigators [27] where a large size equal to or larger than 68 cm^3 was found to be a significant predictor for surgery. Significantly, large cysts are more likely to compress neurovascular structures and narrow CSF spaces as cerebral aqueduct and foramina of Monro, causing hydrocephalus. This is besides a larger size of the cysts is considered a potential risk factor for cyst rupture [51, 61]. Progression or expansion of the arachnoid cyst is unlikely to occur according to the natural history of these cysts [62]. But if it happened, this radiological progression should not be an absolute indication for surgical intervention that should be reserved only for rapidly enlarging symptomatic cases [63]. Serial imaging for progressive arachnoid cysts is the most wise management where most of these cases remain asymptomatic with favorable outcome [64]; besides, there are many reports on regression and spontaneous resolution [65–67]. Even in young age which is related significantly to cyst growth, observational management should be followed as this rapid growth is retarded over time till it reaches a plateau and no further progression was found in children older than 3 or 4 years [64, 68] at the time of diagnosis.

Indications based on work-up studies

Because active CSF production from the cyst wall is one of the possible mechanisms for cyst expansion that was proved recently [10], it may be important to identify non-communicating cysts that are at higher risk of progression in comparison to cysts communicating to the surrounding subarachnoid space or ventricles. For this purpose, studies utilizing CT cisternography and phase contrast cine flow MR sequences were performed to identify non-communicating cysts. In one study, 22 out of the 28 patients studied had incomplete communicating or non-communicating cysts [69], and in another one, the cine flow MR showed that 20 out of 28 patients had non-communicating cysts [70]. All patients with non-communicating cysts were operated upon by microsurgical fenestrations with postoperative reduction of size in all of them, while all other communicating cysts were followed up for more than 3 years without detection of any progression.

Prophylactic surgery

The risk of arachnoid cyst rupture associated with large cyst size or exposure to trauma had led to the rise of the question of prophylactic surgery for these cysts. The rationale for the debate was the reported cases of spontaneous rupture, the reported cases of sports-related head injury associated with arachnoid cyst ruptures, besides the studies describing the arachnoid cyst as a risk for chronic subdural hematoma secondary to their rupture [71–74]. In a survey addressing the management of an incidental finding of a sylvian arachnoid cyst following head trauma, 17.7% of the participants were in favor of prophylactic surgery [22]. However, the value of preventive surgery was challenged by many authors, and a consensus was established that there is no practical role for prophylactic surgery for arachnoid cyst [18, 49]. This consensus was based on many facts; first, there are many reports about incidentally found arachnoid cysts in posttraumatic imaging, and none of these reported cases had showed cyst related hemorrhage or hygroma [75–77]. The second fact is that although hemorrhage in arachnoid cyst was occasionally reported as a complication of athletic participation for those patients, this hemorrhage was rare and almost had a good long-term outcomes that made neurosurgeons reluctant to justify prophylactic surgery or even sport restriction for those patients [78]. The same was found also for subdural hygroma complicating arachnoid cyst rupture where those patients had long-lasting spontaneous resolution of their symptoms with conservative management [79]. The third fact was about the risk of surgical treatment itself where the risk of postoperative subdural hematoma/hygroma was reported to be around 5% which is similar or even higher than the risk reported for spontaneous or traumatic cases [37]. It should be mentioned also in this context that the surgery might not guarantee the prevention of cyst rupture as was found in one study where 10% of a series of an endoscopically managed sylvian arachnoid cysts developed subdural hematoma or hygroma in the follow-up period in spite of the MR evidence of reduction of cyst volume in 50% of them [33].

Conclusion

The decision for surgical intervention for pediatric arachnoid cysts is not a simple one and highly debatable; however, there is a consensus that the occurrence of symptoms definitely correlated to the presence of these cysts or their rupture with consequent subdural hematoma or hygroma are indications for surgical intervention. Large cysts in locations compressing CSF pathways causing hydrocephalus are also candidates for surgical fenestration. The growing experience with the management of sylvian arachnoid cysts points to more conservative strategy without intervention even with large cysts unless there is an increase of intracranial pressure. The surgical gain from prophylactic surgery is questionable particularly when asymptomatic.

Author contribution The main idea of the article was postulated by Mohamed El Beltagy, while literature search was performed by Abdelrhman Enayet. Both authors shared analysis of the data in the literature. The draft was written by Abdelrhman Enayet, and the manuscript was critically revised and reviewed by Mohamed El Beltagy.

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Declarations

Ethics approval and consent to participate Not applicable.

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References

1. Rengachary SS, Watanabe I (1981) Ultrastructure and pathogenesis of intracranial arachnoid cysts. J Neuropathol Exp Neurol 40(1):61–83
2. Rengachary SS, Watanabe I, Brackett C (1978) Pathogenesis of intracranial arachnoid cysts. Surg Neurol 9(2):139–144
3. Choi JU, Kim DS (1998) Pathogenesis of arachnoid cyst: congenital or traumatic? Pediatr Neurosurg 29(5):260–266
4. Contreras C, Copty M, Langelier R, Gagne F (1977) Traumatic suprasellar arachnoid cyst. Surg Neurol 8(3):196–198
5. Aarhus M, Helland CA, Lund-Johansen M, Wester K, Knappskog PM (2010) Microarray-based gene expression profiling and DNA copy number variation analysis of temporal fossa arachnoid cysts. Cerebrospinal fluid research 7(1):1–8
6. Arriola G, de Castro P, Verdú A (2005) Familial arachnoid cysts. Pediatr Neurol 33(2):146–148
7. Helland CA, Wester K (2007) Monozygotic twins with mirror image cysts: indication of a genetic mechanism in arachnoid cysts? Neurology 69(1):110–111
8. Bayrakli F, Okten AI, Kartal U, Menekse G, Guzel A, Oztoprak I, Kars HZ (2012) Intracranial arachnoid cyst family with autosomal recessive trait mapped to chromosome 6q22. 31–23.2. Acta neurochirurgica 154(7):1287–1292
9. Halani SH, Safain MG, Heilman CB (2013) Arachnoid cyst slit valves: the mechanism for arachnoid cyst enlargement: report of 5 cases. J Neurosurg Pediatr 12(1):62–66
10. Helland CA, Aarhus M, Knappskog P, Olsson LK, Lund-Johansen M, Amiry-Moghaddam M, Wester K (2010) Increased NKCC1 expression in arachnoid cysts supports secretory basis for cyst formation. Exp Neurol 224(2):424–428
11. Sandberg DI, McComb JG, Krieger MD (2005) Chemical analysis of fluid obtained from intracranial arachnoid cysts in pediatric patients. J Neurosurg Pediatr 103(5):427–432
12. Rabiei K, Tisell M, Wikkelsø C, Johansson BR (2014) Diverse arachnoid cyst morphology indicates different pathophysiological origins. Fluids and Barriers of the CNS 11(1):1–11
13. Go KG, Houthoff HJ, Blaauw EH, Havinga P, Hartsuiker J (1984) Arachnoid cysts of the sylvian fissure: evidence of fluid secretion. J Neurosurg 60(4):803–813
14. Schuhmann MU, Tatagiba M, Hader C, Brandis A, Samii M (2000) Ectopic choroid plexus within a juvenile arachnoid cyst of the cerebellopontine angle: cause of cyst formation or reason of cyst growth. Pediatr Neurosurg 32(2):73–76
15. Miyagami M, Kasahara E, Miyazaki S, Tsubokawa T, Kagawa Y (1991) Ultrastructural findings of arachnoid cysts and epithelial cysts. No to Shinkei= Brain and Nerve 43(6):545–553
16. Tandon PN, Roy S, Elvidge A (1972) Subarachnoid ependymal cyst: report of two cases. J Neurosurg 37(6):741–745
17. Berle M, Kroksveen A, Garberg H, Aarhus M, Haaland Ø, Wester K, Berven F (2013) Quantitative proteomics comparison of arachnoid cyst fluid and cerebrospinal fluid collected perioperatively from arachnoid cyst patients. Fluids and Barriers of the CNS 10(1):1–10
18. Di Rocco C (2010) Sylvian fissure arachnoid cysts: we do operate on them but should it be done? Childs Nerv Syst 26(2):173–175
19. Gosalakkal JA (2002) Intracranial arachnoid cysts in children: a review of pathogenesis, clinical features, and management. Pediatr Neurol 26(2):93–98
20. Amelot A, Beccaria K, Blauwblomme T, Bourgeois M, Paternoster G, Cuny ML, Puget S (2019) Microsurgical, endoscopic, and shunt management of pediatric temporosylvian arachnoid cysts: a comparative study. J Neurosurg Pediatr 23(6):749–757
21. Zhu GT, Li CZ, Gui SB, Zhao P, Li ZY, Liu CH, Zhang YZ (2022) Endoscopic fenestration for treating galassi type III middle cranial fossa arachnoid cysts: single-and multiple-stoma have the same curative effect. Journal of Neurological Surgery Part A: Central European Neurosurgery
22. Tamburrini G, Del Fabbro M, Di Rocco C (2008) Sylvian fissure arachnoid cysts: a survey on their diagnostic workout and practical management. Child's Nervous System 24(5):593–604
23. Rocco CD, Novegno F, Trevisi G (2014) The "complex" management of Sylvian fissure arachnoid cysts. In Neuroendoscopy (pp. 175–183). Springer, Berlin, Heidelberg
24. Galassi E, Tognetti F, Gaist G, Fagioli L, Frank F, Frank G (1982) CT scan and metrizamide CT cisternography in arachnoid cysts of the middle cranial fossa: classification and pathophysiological aspects. Surg Neurol 17(5):363–369
25. Pradilla G, Jallo G (2007) Arachnoid cysts: case series and review of the literature. Neurosurg Focus 22(2):1–4
26. Cincu R, Agrawal A, Eiras J (2007) Intracranial arachnoid cysts: current concepts and treatment alternatives. Clin Neurol Neurosurg 109(10):837–843
27. Ali M, Bennardo M, Almenawer SA, Zagzoog N, Smith AA, Dao D, Singh SK (2015) Exploring predictors of surgery and comparing operative treatment approaches for pediatric intracranial arachnoid cysts: a case series of 83 patients. J Neurosurg Pediatr 16(3):275–282
28. Al-Holou WN, Terman S, Kilburg C, Garton HJ, Muraszko KM, Maher CO (2013) Prevalence and natural history of arachnoid cysts in adults. J Neurosurg 118(2):222–231
29. Wester K (1999) Peculiarities of intracranial arachnoid cysts: location, sidedness, and sex distribution in 126 consecutive patients. Neurosurgery 45(4):775–779
30. Choi JW, Lee JY, Phi JH, Kim SK, Wang KC (2015) Stricter indications are recommended for fenestration surgery in intracranial arachnoid cysts of children. Childs Nerv Syst 31(1):77–86
31. Marin-Sanabria EA, Yamamoto H, Nagashima T, Kohmura E (2007) Evaluation of the management of arachnoid cyst of the posterior fossa in pediatric population: experience over 27 years. Childs Nerv Syst 23(5):535–542
32. Karabagli H, Etus V (2012) Success of pure neuroendoscopic technique in the treatment of Sylvian arachnoid cysts in children. Childs Nerv Syst 28(3):445–452
33. Spacca B, Kandasamy J, Mallucci CL, Genitori L (2010) Endoscopic treatment of middle fossa arachnoid cysts: a series of 40 patients treated endoscopically in two centres. Childs Nerv Syst 26(2):163–172
34. Fewel ME, Levy ML, McComb G (1996) Surgical treatment of 95 children with 102 intracranial arachnoid cysts. Pediatr Neurosurg 25(4):165–173

35. Oertel JM, Wagner W, Mondorf Y, Baldauf J, Schroeder HW, Gaab MR (2010) Endoscopic treatment of arachnoid cysts: a detailed account of surgical techniques and results. Neurosurgery 67(3):824–836
36. Talamonti G, D'Aliberti G, Picano M, Debernardi A, Collice M (2011) Intracranial cysts containing cerebrospinal fluid-like fluid: results of endoscopic neurosurgery in a series of 64 consecutive cases. Neurosurgery 68(3):788–803
37. Tamburrini G, Caldarelli M, Massimi L, Santini P, Di Rocco C (2003) Subdural hygroma: an unwanted result of Sylvian arachnoid cyst marsupialization. Childs Nerv Syst 19(3):159–165
38. Di Rocco F, James RS, Roujeau T, Puget S, Sainte-Rose C, Zerah M (2010) Limits of endoscopic treatment of sylvian arachnoid cysts in children. Childs Nerv Syst 26(2):155–162
39. Cinalli G, Spennato P, Ruggiero C, Aliberti F, Trischitta V, Buonocore MC, Maggi G (2007) Complications following endoscopic intracranial procedures in children. Childs Nerv Syst 23(6):633–644
40. Levy ML, Wang M, Aryan HE, Yoo K, Meltzer H (2003) Microsurgical keyhole approach for middle fossa arachnoid cyst fenestration. Neurosurgery 53(5):1138–1145
41. Ali ZS, Lang SS, Bakar D, Storm PB, Stein SC (2014) Pediatric intracranial arachnoid cysts: comparative effectiveness of surgical treatment options. Childs Nerv Syst 30(3):461–469
42. Chan JL, Tan AL, Ng LP, Low DC, Tew SW, Low SY (2021) Paediatric arachnoid cysts: surgical outcomes from a Singapore children's hospital. J Clin Neurosci 85:122–131
43. Cinalli G, Spennato P, Columbano L, Ruggiero C, Aliberti F, Trischitta V, Cianciulli E (2010) Neuroendoscopic treatment of arachnoid cysts of the quadrigeminal cistern: a series of 14 cases. J Neurosurg Pediatr 6(5):489–497
44. Hagebeuk EE, Kloet A, Grotenhuis JA, Peeters EA (2005) Bobblehead doll syndrome successfully treated with an endoscopic ventriculocystocisternostomy: case report and review of the literature. J Neurosurg Pediatr 103(3):253–259
45. Gui SB, Wang XS, Zong XY, Zhang YZ, Li CZ (2011) Suprasellar cysts: clinical presentation, surgical indications, and optimal surgical treatment. BMC Neurol 11(1):1–9
46. Crimmins DW, Pierre-Kahn A, Sainte-Rose C, Zerah M (2006) Treatment of suprasellar cysts and patient outcome. J Neurosurg Pediatr 105(2):107–114
47. Helland CA, Wester K (2007) Intracystic pressure in patients with temporal arachnoid cysts: a prospective study of preoperative complaints and postoperative outcome. J Neurol Neurosurg Psychiatry 78(6):620–623
48. Sgouros S, Chapman S (2001) Congenital middle fossa arachnoid cysts may cause global brain ischaemia: a study with 99Tc-hexamethylpropyleneamineoxime single photon emission computerised tomography scans. Pediatr Neurosurg 35(4):188–194
49. Tamburrini G (2018) Controversies in the management of intracranial arachnoid cysts. In *Arachnoid Cysts* (pp. 93–104). Academic Press
50. Kim KH, Lee JY, Phi JH, Kim SK, Cho BK, Wang KC (2020) Long-term outcome of large sylvian arachnoid cysts: the role of surgery has been exaggerated. J Neurosurg Pediatr 26(3):221–227
51. Balestrino A, Piatelli G, Consales A, Cama A, Rossi A, Pacetti M, Pavanello M (2020) Spontaneous rupture of middle fossa arachnoid cysts: surgical series from a single center pediatric hospital and literature review. Childs Nerv Syst 36(11):2789–2799
52. Iaconetta G, Esposito M, Maiuri F, Cappabianca P (2006) Arachnoid cyst with intracystic haemorrhage and subdural haematoma: case report and literature review. Neurol Sci 26(6):451–455
53. Shrestha R, You C (2014) Spontaneous chronic subdural hematoma associated with arachnoid cyst in children and young adults. Asian journal of neurosurgery 9(3):168
54. Hong JC, Kim MS, Chang CH, Kim SH (2008) Arachnoid cyst with spontaneous intracystic hemorrhage and chronic subdural hematoma. Journal of Korean Neurosurgical Society 43(1):54
55. Huang D, Abe T, Kojima K, Tanaka N, Watauabe M, Ohkura A, Norbash AM (1999) Intracystic hemorrhage of the middle fossa arachnoid cyst and subdural hematoma caused by ruptured middle cerebral artery aneurysm. Am J Neuroradiol 20(7):1284–1286
56. Parsch CS, Krauss J, Hofmann E, Meixensberger J, Roosen K (1997) Arachnoid cysts associated with subdural hematomas and hygromas: analysis of 16 cases, long-term follow-up, and review of the literature. Neurosurgery 40:483–490
57. Oka Y, Kumon Y, Ohta S, Sakaki S, Ohue S, Takeda S (1994) Chronic subdural hematoma associated with middle fossa arachnoid cysts: three case reports. Neurol Med Chir (Tokyo) 34:95–99
58. Adin ME, Yıldız MS, Deniz MA, Behzadi AH, Mata-Mbemba D (2018) Arachnoid cysts with spontaneous intracystic hemorrhage and associated subdural hematoma: report of management and follow-up of 2 cases. Radiol Case Reports 13:516–521
59. Lohani S, Robertson RL, Proctor MR (2013) Ruptured temporal lobe arachnoid cyst presenting with severe back pain. J Neurosurg Pediatr 12:281–283
60. Bora A, Yokuş A, Batur A, Bulut MD, Yavuz A, Gülşen İ, Özgökçe M, Arslan M (2015) Spontaneous rupture of the middle fossa arachnoid cyst into the subdural space: case report. Polish J Radiol 80:324–327
61. Cress M, Kestle JR, Holubkov R, Riva-Cambrin J (2013) Risk factors for pediatric arachnoid cyst rupture/hemorrhage: a case-control study. Neurosurgery 72(5):716–722
62. Hall S, Smedley A, Sparrow O, Mathad N, Waters R, Chakraborty A, Tsitouras V (2019) Natural history of intracranial arachnoid cysts. World neurosurgery 126:e1315–e1320
63. Rao G, Anderson RC, Feldstein NA, Brockmeyer DL (2005) Expansion of arachnoid cysts in children: report of two cases and review of the literature. J Neurosurg Pediatr 102(3):314–317
64. Lee JY, Kim JW, Phi JH, Kim SK, Cho BK, Wang KC (2012) Enlarging arachnoid cyst: a false alarm for infants. Childs Nerv Syst 28(8):1203–1211
65. Cokluk C, Senel A, Celik F, Ergur H (2003) Spontaneous disappearance of two asymptomatic arachnoid cysts in two different locations. Minim Invasive Neurosurg 46(2):110–112
66. Pandey P, Tripathi M, Chandra PS, Singh VP, Mehta VS (2001) Spontaneous decompression of a posterior fossa arachnoid cyst: a case report. Pediatr Neurosurg 35(3):162–163
67. Russo N, Domenicucci M, Beccaglia MR, Santoro A (2008) Spontaneous reduction of intracranial arachnoid cysts: a complete review. Br J Neurosurg 22(5):626–629
68. Al-Holou WN, Yew AY, Boomsaad ZE, Garton HJ, Muraszko KM, Maher CO (2010) Prevalence and natural history of arachnoid cysts in children. J Neurosurg Pediatr 5(6):578–585
69. Wang X, Chen JX, You C, Jiang S (2012) CT cisternography in intracranial symptomatic arachnoid cysts: classification and treatment. J Neurol Sci 318(1–2):125–130
70. Li L, Zhang Y, Li Y, Zhai X, Zhou Y, Liang P (2013) The clinical classification and treatment of middle cranial fossa arachnoid cysts in children. Clin Neurol Neurosurg 115(4):411–418
71. Zuckerman SL, Prather CT, Yengo-Kahn AM, Solomon GS, Sills AK, Bonfield CM (2016) Sport-related structural brain injury associated with arachnoid cysts: a systematic review and quantitative analysis. Neurosurg Focus 40(4):E9
72. Tsuzuki N, Katoh H, Ohtani N (2003) Chronic subdural hematoma complicating arachnoid cyst secondary to soccer-related head injury: case report. Neurosurgery 53(1):242–243
73. Mori K, Yamamoto T, Horinaka N, Maeda M (2002) Arachnoid cyst is a risk factor for chronic subdural hematoma in juveniles: twelve cases of chronic subdural hematoma associated with arachnoid cyst. J Neurotrauma 19(9):1017–1027
74. Wu X, Li G, Zhao J, Zhu X, Zhang Y, Hou K (2018) Arachnoid cyst–associated chronic subdural hematoma: report of 14 cases and a systematic literature review. World Neurosurgery 109:e118–e130

75. Eskandary H, Sabba M, Khajehpour F, Eskandari M (2005) Incidental findings in brain computed tomography scans of 3000 head trauma patients. Surg Neurol 63(6):550–553
76. Ortega HW, Vander Velden H, Reid S (2012) Incidental findings on computed tomography scans in children with mild head trauma. Clin Pediatr 51(9):872–876
77. Rogers AJ, Maher CO, Schunk JE, Quayle K, Jacobs E, Lichenstein R, Kuppermann N (2013) Incidental findings in children with blunt head trauma evaluated with cranial CT scans. Pediatrics 132(2):e356–e363
78. Strahle J, Selzer BJ, Geh N, Srinivasan D, Strahle M, Martinez-Sosa M, Maher CO (2016) Sports participation with arachnoid cysts. J Neurosurg Pediatr 17(4):410–417
79. Maher CO, Garton HJ, Al-Holou WN, Trobe JD, Muraszko KM, Jackson EM (2013) Management of subdural hygromas associated with arachnoid cysts. J Neurosurg Pediatr 12(5):434–443