Child's Nervous System
https://doi.org/10.1007/s00381-024-06352-5

REVIEW

Pediatric non-galenic pial arteriovenous fistula's characteristics and outcomes: a systematic review

Garrett W. Thrash[1] · Andrew T. Hale[2] · Michael J. Feldman[3] · Benjamin W. Saccomano[2] · D. Jonah Barrett[1] · Pedram D. Malenkia[1] · Somnath Das[2] · Georges Bouobda Tsemo[2] · Jeffrey P. Blount[3] · Brandon G. Rocque[3] · Curtis J. Rozzelle[3] · James M. Johnston[3] · Jesse G. Jones[2,4]

Received: 10 January 2024 / Accepted: 1 March 2024
© The Author(s) 2024

Abstract

Introduction Pediatric non-galenic pial arteriovenous fistulas (pAVFs) are rare vascular malformations that are characterized by a pial arterial-venous connection without an intervening capillary bed. Outcomes and treatment strategies for pAVFs are highly individualized, owing to the rarity of the disease and lack of large-scale data guiding optimal treatment approaches.

Methods We performed a systematic review of pediatric patients (< 18 years at diagnosis) diagnosed with a pAVF by digital subtraction angiogram (DSA). The demographics, treatment modalities, and outcomes were documented for each patient and clinical outcome data was collected. Descriptive information stratified by outcome scores were classified as follows: 1 = excellent (no deficit and full premorbid activity), 2 = good (mild deficit and full premorbid activity), 3 = fair (moderate deficit and impaired activity), 4 = poor (severe deficit and dependent on others), 5 = death.

Results A total of 87 studies involving 231 patients were identified. Median age at diagnosis was 3 years (neonates to 18 years). There was slight male preponderance (55.4%), and 150 subjects (81.1%*) experienced excellent outcomes after treatment. Of the 189 patients treated using endovascular approaches, 80.3% experienced excellent outcomes and of the 15 patients surgically treated subjects 75% had an excellent outcome. The highest rate of excellent outcomes was achieved in patients treated with Onyx (95.2%) and other forms of EvOH (100%). High output heart failure and comorbid vascular lesions tended to result in worse outcomes, with only 54.2% and 68% of subjects experiencing an excellent outcome, respectively. *Outcomes were reported in only 185 patients.

Conclusion pAVFs are rare lesions, necessitating aggregation of patient data to inform natural history and optimal treatment strategies. This review summarizes the current literature on pAVF in children, where children presenting with heart failure as a result of high flow through the lesion were less likely to experience an excellent outcome. Prospective, large-scale studies would further characterize pediatric pAVFs and enable quantitative analysis of outcomes to inform best treatment practices.

Keywords Pial arteriovenous fistula · Pial AV fistula · Non-galenic arteriovenous fistula · Non-galenic pial arteriovenous fistula · Pediatric cerebrovascular · Systematic review · Meta analysis

Garrett W. Thrash BS and Andrew T. Hale MD, PhD contributed equally to this work.

✉ Andrew T. Hale
andrewthale20@gmail.com

[1] Heersink School of Medicine, University of Alabama at Birmingham, Birmingham, AL, USA

[2] Department of Neurosurgery, University of Alabama at Birmingham, FOT Suite 1060, 1720 2nd Ave S, Birmingham, AL 35294, USA

[3] Division of Pediatric Neurosurgery, Department of Neurosurgery, University of Alabama at Birmingham, Birmingham, AL, USA

[4] Department of Diagnostic Radiology, University of Alabama at Birmingham, Birmingham, AL, USA

Published online: 20 March 2024

Introduction

Pial arteriovenous fistulas (pAVF), also known as non-galenic arteriovenous fistulas, are vascular malformations that are distinct from arteriovenous malformations (AVM) due to the lack of a nidus between feeding artery and draining vein [1]. Unlike dural arteriovenous fistulas (dAVF), pAVFs involve parenchymal cerebral vasculature rather than meningeal [2]. pAVFs may drain through the vein of Galen (VOG) and still be differentiated from VOG malformations which are primarily fed by choroidal arteries. AV shunting by pAVFs predisposes to venous varix formation, which increases the risk of hemorrhage. pAVFs are rare lesions, contributing to only 1.6% of all brain vascular malformations [3, 4] Digital subtraction angiography (DSA) is recommended for diagnosis and characterization of the angio-architecture.

pAVFs are almost entirely congenital. The majority of diagnoses occur either shortly after birth due to heart failure or cerebral venous congestion/neurologic decline or following spontaneous intracranial hemorrhage later in life [5]. The molecular pathophysiology underlying pAVF formation *in utero* is not well characterized, but thought to involve perturbations in angiogenic growth factors and embryonic vascular morphogenesis [6–8]. The most frequently associated genetic mutations involve the hereditary hemorrhagic telangiectasia (HHT) genes (ENG, ACVRL and SMAD4) and *RASA1* -- which are also implicated in brain AVM and VOGM, respectively [9]. HHT is an autosomal dominant disease characterized by vascular malformations throughout the body [10]. *RASA1* variants affect the RAS/MAPK signaling pathway involved in vascular endothelial cell proliferation [11]. There is increasing recognition, overall, of the contribution of genetic factors to cerebrovascular disease more broadly.

The goal of pAVF treatment is disconnection of the shunt, either through open surgery or endovascular embolization. However, due to the rarity of the condition, there are no consensus guidelines for treatment. Surgical treatment of pAVFs is typically reserved for patients with intracranial hemorrhage causing mass effect and neurologic deterioration, but more commonly endovascular embolization is preferred [2]. In an effort to understand demographic, clinical, and radiological factors associated with treatment outcomes, we performed a systematic review of published pAVF cases in children.

Methods

This systematic review followed PRISMA guidelines [12]. PubMed, CINAHL, Scopus, and Embase databases were queried without a date restriction. The protocol for the review was not registered. Search strategy included MeSH (Medical Subject Heading) terms related to pial arteriovenous fistulas and then translated across each database (see Appendix). Search results were then screened by title and abstract, then full text by two independent reviewers (G.T., J.B.) with discrepancies reviewed by a 3rd author (A.T.H). Articles were included based on the following criteria: (1) Available full text with English translation, (2) pediatric patients less than 18 years old, (3) individual patient data could be retrieved, (4) articles represented primary sources, and 4) pAVF was diagnosed by cerebral angiography. Only case reports, case studies, case series, and cohort studies were included in our analysis. Review articles, meta-analyses, non-human studies, conference papers, and abstracts without full text were excluded. Dependent variables were age, sex, race, cardiovascular disease, venous varix, cerebral hemorrhage, genetic disease, other vascular lesions, feeding artery name, draining vein location (deep/superficial), treatment modality, embolic agent, treatment success, number of stages, and procedural complications. Clinical outcome was identified in 187 patients (80.6%) and scored on a scale of 1–5 using the ranking system utilized by Hoh et al., to score pAVFs based on patient activity and deficit [5].

Results

There were 857 articles identified on initial screening (339 in PubMed, 319 in Embase,169 in Scopus, and 66 in CINAHL) and imported into Covidence. The 469 duplicates were automatically removed. Initial title and abstract screening removed another 224 articles, leaving 164 studies for full text review. Of these, 87 were included for data extraction based upon the aforementioned criteria. The other 77 manuscripts were removed due to the reasons found in Fig. 1. A summary of all included cases can be seen in supplemental material 1 [1–98].

In total, 231 pediatric patients harboring pAVF were identified. Median age was 3 years (< 1 month to 18 years). Slightly more patients were male (55.4%). Sixty-seven and one-half percent of subjects were symptomatic at diagnosis, most often from intracranial hemorrhage or high output heart failure (HOHF). Other presentations included headache (9.5%), seizures (12.1%), growth delay (5.2%) and macrocephaly (2.2%). All 39 patients presenting with HOHF were diagnosed in the neonatal period. Approximately half

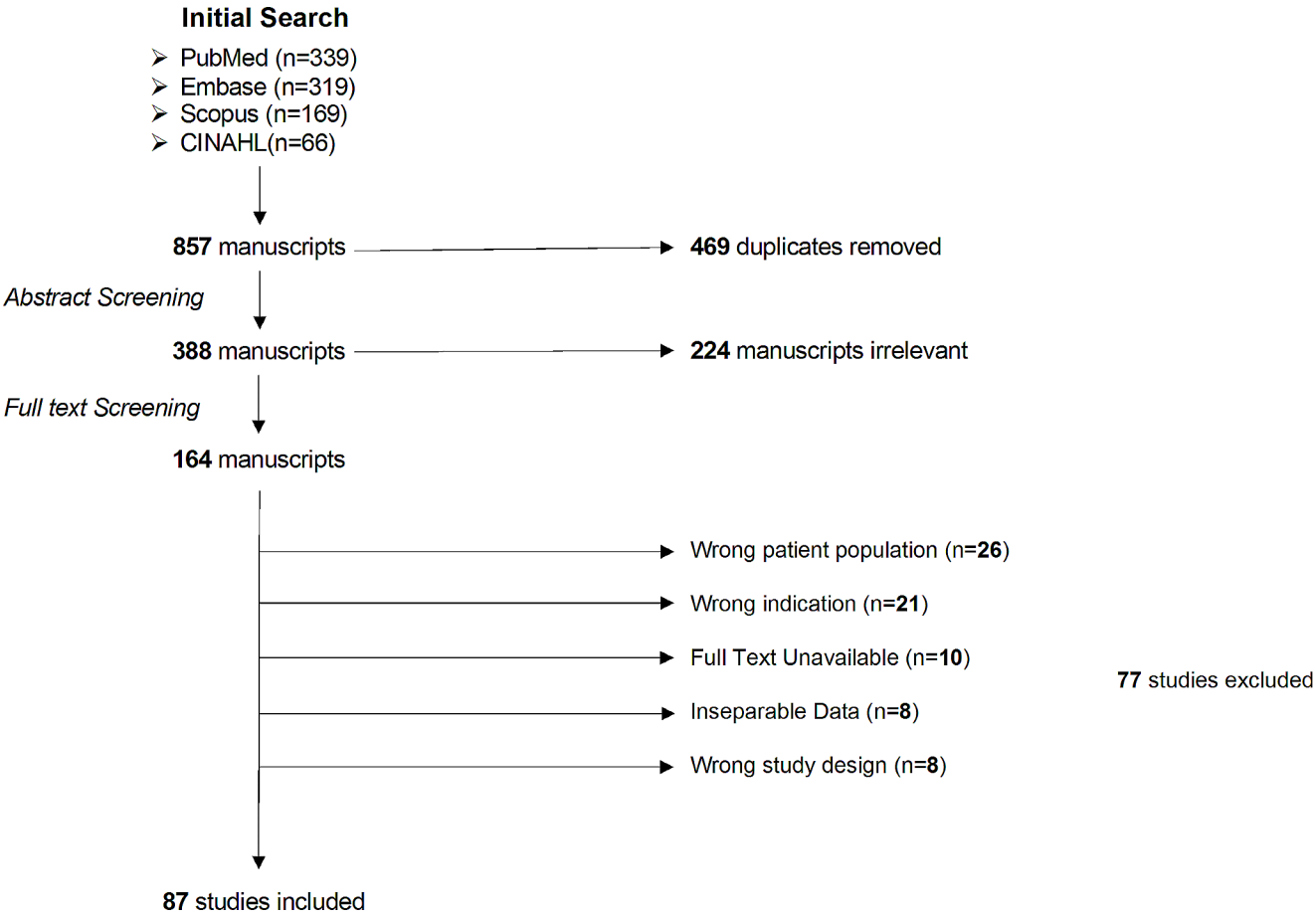

Fig. 1 PRISMA flow diagram describing the results of our systematic review

of subjects exhibited venous varices. One fifth of the cohort had an underlying genetic condition attributable to *RASA1* (12.6%) or HHT (5.6%) mutations, among others (Table 1). One patient was diagnosed with Moya-Moya syndrome and another with Encephalocraniocutaneous lipomatosis. The major feeding arteries to the pAVF included the middle cerebral (MCA) (16.9%), posterior cerebral (PCA) (11.7%), anterior cerebral (ACA) (10%) and posterior inferior cerebellar arteries (PICA) (5.2%). Another 28 patients (12.3%) had unrelated coexisting vascular lesions, such as AVM or intracranial aneurysm (Table 1).

The median clinical follow up was 9 months, with a range of 3 months to 6 years. Of the 185 patients with reported outcomes data, 150 patients (81.1%) experienced an excellent outcome (Table 2). Among those with less than excellent outcomes, 8.6% were good outcome, 4.3% fair, 1.1% poor, and 4.9% experienced any-cause mortality. There were two intraoperative deaths. One from vessel perforation during endovascular treatment and the other from acute sinus thrombosis during open surgery [13, 14]. First time angiographic success (i.e., complete obliteration of the fistula) was achieved in 76.3% (135 patients). One patient experienced spontaneous involution. Twenty-nine subjects (12.6%) underwent a second treatment (Table 3) although whether staging was intentional could rarely be ascertained. Of those who underwent a 2nd treatment, 23 of those patients experienced complete obliteration. When accounting for obliterations after the 2nd treatment, the rate of complete obliteration rose to 89.2%. Procedural complications occurred in 21.6% of cases. Of the complications, 14.5% were transient (< 12 months duration) and 6.9% permanent. Major complications included cardiac arrest and venous sinus thrombosis. The infant with cardiac arrest was successfully resuscitated [15]. The patient who experienced venous thrombosis was treated with anti-coagulation and anti-platelet therapy and showed complete resolution at the 6-month follow-up [16]. Endovascular procedural complications consisted of distal embolic migration into the cerebral veins and lungs [17]. Subsequent venous congestion led to seizures in one subject [18]. Of the 13 permanent complications, 9 resulted in death. The 2 immediate peri-operatively mortalities were due to vessel perforation and acute sinus thrombosis. The 7 remaining patients died shortly post-op with 2 succumbing to brain death (not otherwise specified)

Table 1 Patient demographics, genetic disease prevalence and angioarchitecture of the fistulae. Abbreviations include ACA- Anterior Cerebral Arter, CVD- cardiovascular disease, HHT- hereditary hemorrhagic telangiectasia, ICA- Internal Carotid Artery, MCA- Middle Cerebral Artery, N/A – not available, PCA- Posterior Cerebral Artery, PICA- Posterior Inferior Cerebellar Artery, SCA- Superior Cerebral Artery, SD-Standard Deviation, SSS- Superior Sagittal Sinus, and VOG- Vein of Galen

Variable	Value
Total # of patients	231
Sex	
Male	128 (55.4%)
Female	87(37.7%)
Missing	16(6.9%)
Mean age (SD), years	5.4(5.7)
Median Age, years	3.0
Race	Only 2 Cases Reported
HOHF	
Yes	39(16.9%)
No	192(83.1%)
Venous Varix	
Yes	114(49.3%)
No	117(50.7%)
Hemorrhage	
Yes	48(20.7%)
No	183(79.2%)
All-Cause Mortality	9 (3.9%)
Genetic Disease	
RASA1	29(12.6%)
HHT	13(5.6%)
Other	7(3.0%)
Not Mentioned	182(78.8%)
Presentation	
Asymptomatic	11(4.7%)
Symptomatic	156 (67.5%)
Feeding Arteries	
MCA	39(16.9%)
PCA	27(11.7%)
PICA	12(5.2%)
ACA	23(10.0%)
ICA	3(1.3%)
SCA	3(1.3%)
Other	29(12.6%)
Missing	96(41.6%)
Venous Drainage	
SSS	11(4.8%)
Transverse Sigmoid Sinus	5(2.2%)
VOG	11(4.8%)
Straight Sinus	12(5.2%)
Sylvian	4(1.7%)
Sigmoid Sinus	7(3.0%)
Other	30(13.0%)
Missing	151(65.4%)
Coexisting Vascular Lesions	
Yes	28(12.1%)
Diagnosed with Genetic Disease	12 (42.8%)

Table 2 Treatment outcomes, obliteration rates, and complications during intervention. Outcome scores were adopted from Hoh, Putman, Budzik, et al., 2001 [5]. Outcomes were classified in the following manner: 1 = excellent (no deficit and full premorbid activity), 2 = good (mild deficit and full premorbid activity), 3 = fair(moderate deficit and impaired activity), 4 = poor (severe deficit and dependent on others), 5 = death. Those who received a 2nd treatment received obliteration

Variable	Value
Outcome Score	
1	150(81.1%)
2	16(8.6%)
3	8(4.3%)
4	2(1.1%)
5	9(4.8%)
Missing	46
Angiographic Outcome	
Obliteration	135(76.3%)
Spontaneous Angiographic Cure	1(0.5%)
Residual Pathology	12(6.7%)
Required 2nd Treatment	29(16.4%)
Missing	54
Complications	
None	146(78.4%)
Temporary	27(14.5%)
Permanent	13(6.9%)
Missing	48

Table 3 Treatment modalities and number of interventions needed for fistula obliteration. Abbreviations include: nBCA- n-Butyl cyanoacrylate and EvOH-ethyl vinyl alcohol

Variable	Value
Monomodal Therapy	
Embolization	189(81.8%)
Surgery	20(8.7%)
No Treatment	2(0.9%)
Radiosurgery	-
Multimodal Therapy	
Embolization + Surgery	10(4.3%)
Embolization + Radiosurgery	-
Embolization + Surgery + Radio Surgery	1(0.4%)
Total	11
Number of Interventions	
Single Intervention	195(84.4%)
2 or more interventions	31(13.4%)
Type of Embolic Agent	
Liquid	49(25.9%)
Coils	42(22.2%)
Liquid + Coils	40(21.2%)
Missing	58(30.7%)
Type of Liquid Embolic	
Onyx	21(22.8%)
Other Glue	4(4.3%)
nBCA	58(63.0%)
EvOH	9(9.8%)

and 5 to post-embolization hemorrhage. Six of the 9 patients were neonates.

Almost all subjects underwent treatment (Table 4). Endovascular embolization was the most common treatment, (81.8%) followed by open surgery (8.7%) and radiation (0.4%). Combination therapy was employed in 5.2% of cases. Among endovascular techniques, pure liquid (25.9%), coils (22.2%) and a combination of coils and liquid (21.2%) were used. Of the endovascularly treated patients, 80.3% of patients achieved an excellent outcome compared to 75% of surgically treated patients. Of the patients treated with multimodal therapy, 9 of the patients underwent the therapy as part of a second treatment option. Patients treated with Onyx, a type of liquid embolic system that consists of ethyl vinyl alcohol (EvOH), dimethyl sulfoxide (DMSO) and tantalum powder, experienced 95.2% excellent outcomes while all patients treated with other types of EvOH had excellent outcomes. HOHF reduced excellent outcomes to 45.8% and the presence of coexisting vascular lesions had only a 68.5% rate of excellent outcomes.

Table 4 Outcomes data of differing embolic treatments. The scores are represented by the following: 1 = excellent (no deficit and full premorbid activity), 2 = good (mild deficit and full premorbid activity), 3 = fair (moderate deficit and impaired activity), 4 = poor (severe deficit and dependent on others), 5 = death. Abbreviations include: nBCA- n-Butyl cyanoacrylate, EvOH-ethyl vinyl alcohol, and CVD-cardiovascular disease

Variable	Outcome = 1	Outcome = 2–5
Surgery	15(75%)	5(25%)
Endovascular	118(80.3%)	29(19.7%)
Single Modality	77(88.5%)	10(11.5%)
Multiple Modalities	9(81.8%)	-
Coils	49(77.8%)	14(22.2%)
Liquid	78(84.8%)	14(15.2%)
nBCA	46(79.3%)	12(20.7%)
Onyx	20(95.2%)	1(4.8%)
Other EvOH	7(100%)	-
Presented with Venous Varix	83 (82.2%)	18 (17.8%)
Presented with Hemorrhage	32 (80%)	8(20%)
Presented with CVD	11(45.8%)	13(54.2%)
Reported Genetic Disease	14(82.4%)	3(17.6%)
Coexisting Vascular Lesions	17 (68%)	8(32%)

Discussion

Here we perform a systematic review of pAVF outcomes in children. While meta-analysis was not feasible owing to low sample size and the large number of case reports, we observed some patterns worth mentioning. First, those presenting with > 1 vascular malformation were likely to harbor an underlying genetic condition such as HHT or RASA1. Genetic testing should be considered in these cases [19]. Second, the presence of a venous varix was strongly associated with symptomatic and/or hemorrhagic presentation, implicating the varix as a high-risk feature.

Despite young average age at presentation, most patients (over 80%) experienced an excellent outcome. Patients treated with endovascular therapy alone or in combination achieved the highest rate of excellent outcomes, although several stages may be required to completely occlude the pAVF. Patients with HOHF were least likely to experience excellent outcome, possibly reflecting the severity of arteriovenous shunting and downstream effects on the brain and other organs. Poor outcomes clustered in the neonatal group, with most survivors demonstrating recovery from complications and normal development following complete treatment. Overall, this summative data represents the largest descriptive pediatric pAVF cohort.

The amount of missing data encountered in this study highlights the importance of standardized reporting that includes subject-level granularity. Common data elements reduce bias associated with missing results. This shortcoming is exaggerated in similar reviews of rare pathologies in the neurosurgical literature that by nature involve small sample size [6]. Another limitation is publication bias intrinsic to systematic reviews. Many potentially important variables could not be controlled for, such as length of follow-up, operator experience and treatment timing. Small sample size and the retrospective nature of all studies precluded statistical analysis.

Conclusions

pAVFs are rare pediatric vascular anomalies with overall favorable outcome except when associated with heart failure or multifocal vascular lesions. Treatment appears well-tolerated and primarily involves endovascular embolization. This review encompasses the largest descriptive review of pediatric pAVFs. However, the included studies were entirely retrospective and primarily single center, limiting generalizability and with significant risk of bias. Further studies to delineate pAVF natural history and optimal treatment paradigm are needed and should conform to a standardized reporting format to facilitate metanalysis.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00381-024-06352-5.

Acknowledgements Thank you to Ms. Emma O'Hagan, a medical librarian at UAB Lister Hill Library of Health Sciences, for designing the literature search of the material and Dr. Kathryn Kaiser for assistance with Covidence templates and data extraction.

Author contributions Andrew T. Hale conceived and designed the study. Material preparation and data extraction were performed by Garrett W. Thrash and D. Jonah Barrett. The first draft of the manuscript was written by Garrett W. Thrash, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Funding Not applicable.

Data availability Datasets and search terms for this systematic review can be found in the appendix below.

Declarations

Ethics approval and consent to participate Approved by all participating parties.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit http://creativecommons.org/licenses/by/4.0/.

References

1. Geibprasert S, Pongpech S, Jiarakongmun P, Shroff MM, Armstrong DC, Krings T (2010) Radiologic assessment of brain arteriovenous malformations: what clinicians need to know. Radiographics 30(2):483–501. https://doi.org/10.1148/rg.302095728From NLM Medline
2. Upchurch K, Feng L, Duckwiler GR, Frazee JG, Martin NA, Vinuela F (2006) Nongalenic arteriovenous fistulas: history of treatment and technology. Neurosurg Focus 20(6):E8. https://doi.org/10.3171/foc.2006.20.6.8 From NLM Medline
3. Lenck S, Nicholson P, Tymianski R, Hilditch C, Nouet A, Patel K, Krings T, Tymianski M, Radovanovic I, Mendes Pereira V (2019) Spinal and paraspinal arteriovenous lesions. Stroke 50(8):2259–2269. https://doi.org/10.1161/STROKEAHA.118.012783From NLM Medline
4. Halbach VV, Higashida RT, Hieshima GB, Hardin CW, Dowd CF, Barnwell SL (1989) Transarterial occlusion of solitary intracerebral arteriovenous fistulas. AJNR Am J Neuroradiol 10(4):747–752 From NLM Medline
5. Hoh BL, Putman CM, Budzik RF, Ogilvy CS (2001) Surgical and endovascular flow disconnection of intracranial pial single-channel arteriovenous fistulae. Neurosurgery 49(6):1351–1363 discussion 1363–1354. https://doi.org/10.1097/00006123-200112000-00011
6. Lim J, Kuo CC, Waqas M, Cappuzzo JM, Monteiro A, Baig AA, Snyder KV, Davies JM, Levy EI, Siddiqui AH (2023) A systematic review of non-galenic pial arteriovenous fistulas. World Neurosurg 170:226–235e223. https://doi.org/10.1016/j.wneu.2022.09.007From NLM Medline
7. Phatouros CC, Halbach VV, Dowd CF, Lempert TE, Malek AM, Meyers PM, Higashida RT (1999) Acquired pial arteriovenous fistula following cerebral vein thrombosis. Stroke 30(11):2487–2490. https://doi.org/10.1161/01.str.30.11.2487From NLM Medline
8. Shweiki D, Itin A, Soffer D, Keshet E (1992) Vascular endothelial growth factor induced by hypoxia may mediate hypoxia-initiated angiogenesis. Nature 359(6398):843–845. https://doi.org/10.1038/359843a0From NLM Medline
9. Zhao S, Mekbib KY, van der Ent MA, Allington G, Prendergast A, Chau JE, Smith H, Shohfi J, Ocken J, Duran D et al (2023) Mutation of key signaling regulators of cerebrovascular development in vein of Galen malformations. Nat Commun 14(1):7452. https://doi.org/10.1038/s41467-023-43062-zFrom NLM Medline
10. Han Y, Ding B, Li M, Song X, Liu L, Zhou H (2022) A case of hereditary hemorrhagic telangiectasia and literature review. J Clin Lab Anal 36(8):e24571. https://doi.org/10.1002/jcla.24571From NLM Medline
11. Revencu N, Fastre E, Ravoet M, Helaers R, Brouillard P, Bisdorff-Bresson A, Chung CWT, Gerard M, Dvorakova V, Irvine AD et al (2020) RASA1 mosaic mutations in patients with capillary malformation-arteriovenous malformation. J Med Genet 57(1):48–52. https://doi.org/10.1136/jmedgenet-2019-106024From NLM Medline
12. Salameh JP, Bossuyt PM, McGrath TA, Thombs BD, Hyde CJ, Macaskill P, Deeks JJ, Leeflang M, Korevaar DA, Whiting P et al (2020) Preferred reporting items for systematic review and meta-analysis of diagnostic test accuracy studies (PRISMA-DTA): explanation, elaboration, and checklist. BMJ 370:m2632. https://doi.org/10.1136/bmj.m2632From NLM Medline
13. Komiyama M, Terada A, Ishiguro T (2016) Neuro-interventions for the neonates with Brain Arteriovenous Fistulas: with Special Reference to Access routes. Neurol Med Chir (Tokyo) 56(3):132–140. https://doi.org/10.2176/nmc.oa.2015-0336From NLM Medline
14. Zaidi HA, Kalani MY, Spetzler RF, McDougall CG, Albuquerque FC (2015) Multimodal treatment strategies for complex pediatric cerebral arteriovenous fistulas: contemporary case series at Barrow Neurological Institute. J Neurosurg Pediatr 15(6):615–624 14468 From NLM Medline
15. Pillai A, Rajeev K, Unnikrishnan M (2006) Surgical management of a pial arteriovenous fistula with giant varix in an infant. Neurol India 54(4):434–436. https://doi.org/10.4103/0028-3886.28124From NLM Medline
16. Yang J, Kwon OK, Oh CW, Hwang G, Song KS, Lee YJ, Bang JS (2013) Surgical flow disconnection of cerebral pial dual-channel arteriovenous fistula with a large varix: the role of anti-platelet agent or anti-coagulation therapy. Childs Nerv Syst 29(6):1021–1025. https://doi.org/10.1007/s00381-013-2025-8From NLM Medline
17. Vinuela F, Drake CG, Fox AJ, Pelz DM (1987) Giant intracranial varices secondary to high-flow arteriovenous fistulae. J Neurosurg 66(2):198–203. https://doi.org/10.3171/jns.1987.66.2.0198From NLM Medline
18. Youn SW, Han MH, Kwon BJ, Kang HS, Chang HW, Kim BS (2010) Coil-based endovascular treatment of single-hole cerebral arteriovenous fistulae: experiences in 11 patients. World Neurosurg 73(1):2–10 discussion e11. https://doi.org/10.1016/j.surneu.2009.06.001
19. Kahle KT, Duran D, Smith ER (2023) Increasing precision in the management of pediatric neurosurgical cerebrovascular diseases with molecular genetics. J Neurosurg Pediatr 31(3):228–237. https://doi.org/10.3171/2022.12.PEDS22332From NLM Medline

20. Ago M, Masumoto K, Uchiyama A, Aihara Y, Okada Y, Kusuda S (2017) Serial Measurement of Superior Vena Cava Flow in evaluation of the clinical severity of Pial Arteriovenous Fistula in an infant. AJP Rep 7(1):e1–e4. https://doi.org/10.1055/s-0036-1597572From NLM PubMed-not-MEDLINE
21. Aguilar M, Gonzalez A, Lopez A, Gutierrez I, Durand F, Mayol A (2011) Endovascular treatment of a pial arteriovenous fistula with occipital remodeling secondary to giant torcular dilation. J Child Neurol 26(8):1015–1020 10.1177/0883073810397363 From NLM Medline
22. Akamatsu Y, Hayashi T, Sato K, Karibe H, Kameyama M, Tominaga T (2018) Bilateral Upper Cerebellar Hemorrhage due to Pial Arteriovenous Fistula and its pathophysiological insight. World Neurosurg 115:388–392. https://doi.org/10.1016/j.wneu.2018.05.010From NLM Medline
23. Altschul D, Paramasivam S, Ortega-Gutierrez S, Fifi JT, Berenstein A (2014) Safety and efficacy using a detachable tip microcatheter in the embolization of pediatric arteriovenous malformations. Childs Nerv Syst 30(6):1099–1107. https://doi.org/10.1007/s00381-014-2404-9From NLM Medline
24. Alurkar A, Karanam LS, Nayak S, Ghanta RK (2016) Intracranial pial arteriovenous fistulae: diagnosis and treatment techniques in Pediatric patients with review of literature. J Clin Imaging Sci 6:2. https://doi.org/10.4103/2156-7514.175083From NLM PubMed-not-MEDLINE
25. Auyeung KM, Laughlin S, Terbrugge KG (2003) Prenatal diagnosis of unusual fetal pial arteriovenous malformation. A case report. Interv Neuroradiol 9(2):163–168 10.1177/159101990300900205 From NLM PubMed-not-MEDLINE
26. Bankole NDA, Listrat KJA, Travers N, Maldonado IL (2020) Stephane Velut Child pial arteriovenous fistula of the conus medullaris presenting with spinal cord venous congestion: Case report and literature review. *Interdisciplinary Neurosurgery 25*. https://doi.org/10.1016/j.inat.2021.101128
27. Batista LL, Mahadevan J, Sachet M, Husson B, Rasmussen J, Alvarez H, Lasjaunias P (2002) Encephalocraniocutaneous lipomatosis syndrome in a child: association with multiple high flow cerebral arteriovenous fistulae. Case report and review. Interv Neuroradiol 8(3):273–283 10.1177/159101990200800307 From NLM PubMed-not-MEDLINE
28. Berestov V, Seleznev P, Obedinskaya N, Korostyshevskaya A, Gofer J, Bondarenko I, Kiselev R, Krasilnikov S, Brusyanskaya A, Orlov K (2022) Huge cerebral pial arteriovenous fistula in a newborn: illustrative case. J Neurosurg Case Lessons *4* (16). DOI: 10.3171/CASE22294 From NLM PubMed-not-MEDLINE.
29. Bongetta D, Lafe E, Pugliese R, Cattalani A, Gaetani P, Thyrion FZ (2015) Endovascular embolization of pial arteriovenous fistula fed from P1 segment of posterior cerebral artery in 12 years old girl: case report and review of literature. Neuroradiol J 28(3):268–273 10.1177/1971400915589690 From NLM Medline
30. Cooke D, Tatum J, Farid H, Dowd C, Higashida R, Halbach V (2012) Transvenous embolization of a pediatric pial arteriovenous fistula. J Neurointerv Surg 4(4):e14. https://doi.org/10.1136/neurintsurg-2011-010028From NLM Medline
31. Coubes P, Humbertclaude V, Rodesch G, Lasjaunias P, Echenne B, Frerebeau P (1996) Total endovascular occlusion of a giant direct arteriovenous fistula in the posterior fossa in a case of Rendu-Osler-Weber disease. Childs Nerv Syst 12(12):785–788 DOI: 10.1007/BF00261599 From NLM Medline
32. Cuoco JA, Guilliams EL, Apfel LS, Marvin EA, Patel BM (2021) Incidental Pediatric High-Flow Nongalenic Giant Pial Arteriovenous Fistula. Neuropediatrics 52(1):65–68. https://doi.org/10.1055/s-0040-1716905From NLM Medline
33. da Silva Martins WC, de Albuquerque LA, de Souza Filho CB, Dellaretti M, de Sousa (2015) A. A. Surgical treatment of the intracranial pial arteriovenous fistula. Surg Neurol Int 6:102. https://doi.org/10.4103/2152-7806.158518From NLM PubMed-not-MEDLINE
34. Demartini Z, Koppe GL, de Correa B, Keijiro A, Francisco AN (2020) Maranha Gatto, L. A. Matas test revisited: carotid compression for embolization of high-flow pediatric pial arteriovenous fistulas. J Neurosurg Pediatr 27(3):364–367. https://doi.org/10.3171/2020.7.PEDS20401From NLM Medline
35. Deniwar MA, Ahmad S, Eldin AE (2022) Transarterial embolization of intracranial arteriovenous fistulas with large venous pouches in the form of venous outlet Ectasia and large venous varix or aneurysm: two centers experience. J Korean Neurosurg Soc 65(1):30–39. https://doi.org/10.3340/jkns.2021.0116From NLM PubMed-not-MEDLINE
36. Lei Feng YL, Liu J, Lv C, Su C (2016) Pial arteriovenous fistulas: two pediatric cases and a literature review. Int J Clin Exp Med 9(5):7855–7862
37. Fry L, Brake A, Lei C, Stefano FA, Bhargav AG, Peterson J, Ebersole K (2023) Curative transvenous embolization for congenital multi-hole pial arteriovenous fistula. J Cerebrovasc Endovasc Neurosurg. https://doi.org/10.7461/jcen.2023.E2022.07.010 From NLM Publisher
38. Garcia-Monaco R, Taylor W, Rodesch G, Alvarez H, Burrows P, Coubes P, Lasjaunias P (1995) Pial arteriovenous fistula in children as presenting manifestation of Rendu-Osler-Weber disease. Neuroradiology 37(1):60–64 DOI: 10.1007/BF00588522 From NLM Medline
39. Garel C, Azarian M, Lasjaunias P, Luton D (2005) Pial arteriovenous fistulas: dilemmas in prenatal diagnosis, counseling and postnatal treatment. Report of three cases. Ultrasound Obstet Gynecol 26(3):293–296 1002/uog.1957 From NLM Medline
40. Ghorbani M, Wipplinger C, Griessenauer CJ, Hejazian SE, Abadi FZ, Asaadi S (2019) Pial arteriovenous fistula with multiple venous aneurysms resembling a vein of Galen Aneurysmal Malformation; Case Report and Review of Literature. World Neurosurg 127:245–248. https://doi.org/10.1016/j.wneu.2019.04.061From NLM Medline
41. Goel A, Jain S, Shah A, Rai S, Gore S, Dharurkar P (2018) Pial arteriovenous fistula: a brief review and report of 14 surgically treated cases. World Neurosurg 110:e873–e881. https://doi.org/10.1016/j.wneu.2017.11.121From NLM Medline
42. Gonzalez LF, Chalouhi N, Jabbour P, Teufack S, Albuquerque FC, Spetzler RF (2013) Rapid and progressive venous thrombosis after occlusion of high-flow arteriovenous fistula. World Neurosurg 80(6):e359–365. https://doi.org/10.1016/j.wneu.2012.10.043From NLM Medline
43. Guerra LR, Barbosa Lde A, Barbosa LG, Pimentel Dde P, Leite FI (2011) Pial arteriovenous fistula in the posterior fossa. Arq Neuropsiquiatr 69(4):718–719. https://doi.org/10.1590/s0004-282x2011000500028From NLM Medline
44. Guimaraens L, Casasco A, Sola T, Cuellar H, Miralbes S, Cambra FJ (2011) Endovascular treatment of a pial arteriovenous fistula of a posteroinferior cerebellar artery with a double origin. J Neurointerv Surg 3(3):233–236. https://doi.org/10.1136/jnis.2010.003749From NLM Medline
45. Han L, Wang J, Chen J, Lei T (2013) Pial arteriovenous fistula with giant venous varix and dilation of vein of Galen, treated with surgical clipping. Acta Neurochir (Wien) 155(8):1571–1572. https://doi.org/10.1007/s00701-013-1731-zFrom NLM Medline
46. Hatayama K, Goto S, Nishida A, Inoue M (2018) Pial arteriovenous fistula of the spine in a child with hemiplegia. Clin Case Rep 6(6):1132–1136. https://doi.org/10.1002/ccr31557 From NLM PubMed-not-MEDLINE
47. Ito M, Yamamoto T, Mishina H, Sonokawa T, Sato K (2000) Arteriovenous malformation of the medulla oblongata supplied by the anterior spinal artery in a child: treatment by microsurgical

obliteration of the feeding artery. Pediatr Neurosurg 33(6):293–297 10.1159/000055974 From NLM Medline
48. Izzo R, Alvaro Diano A, Lavanga A, Vassallo P, Muto M (2007) Posterior fossa arteriovenous pial fistula: diagnostic and endovascular therapeutic features. A case report. Neuroradiol J 19(6):783–786 10.1177/197140090601900615 From NLM PubMed-not-MEDLINE
49. Jin H, Meng X, Quan J, Lu Y, Li Y (2021) Role of endovascular embolisation for curative treatment of intracranial non-galenic pial arteriovenous fistula. Stroke Vasc Neurol 6(2):260–266. https://doi.org/10.1136/svn-2020-000482From NLM Medline
50. Koroglu M, Cil B, Yesildag A, Baykal B, Cekirge S, Oyar O (2006) Prenatal diagnosis of intracranial pial arteriovenous fistula and endovascular treatment during the neonatal period. Diagn Interv Radiol 12(2):64–67 From NLM Medline
51. Kalra N, Tong L, McCullagh H, Goddard T, Tyagi A (2020) Surgical Disconnection of a residual Pediatric Pial Arteriovenous fistula following partial embolization: a Case Study. World Neurosurg 138:227–230. https://doi.org/10.1016/j.wneu.2020.02.146From NLM Medline
52. Keskin S, Gokmen E, Koc O, Cengiz SL (2015) Intracerebral Pial Arteriovenous Fistula with Aneurysm. Am J Med Sci 350(4):e4 10.1097/MAJ.0000000000000452 From NLM Medline
53. Kraneburg UM, Nga VD, Ting EY, Hui FK, Lwin S, Teo C, Chou N, Yeo TT (2014) Intracranial pial arteriovenous fistula in infancy: a case report and literature review. Childs Nerv Syst 30(2):365–369. https://doi.org/10.1007/s00381-013-2217-2From NLM Medline
54. Kuwabara M, Sakamoto S, Okazaki T, Oshita J, Taguchi A, Kurisu K (2020) Pediatric pial arteriovenous fistula located at the bottom of the callosal sulcus presenting with intraventricular hemorrhage: a case report and literature review. Childs Nerv Syst 36(12):3129–3133. https://doi.org/10.1007/s00381-020-04635-1From NLM Medline
55. Lee JY, Son YJ, Kim JE (2008) Intracranial pial arteriovenous fistulas. J Korean Neurosurg Soc 44(2):101–104. https://doi.org/10.3340/jkns.2008.44.2.101From NLM PubMed-not-MEDLINE
56. Lee JS, Oh CW, Bang JS, Kwon OK, Hwang G (2012) Intracranial pial arteriovenous fistula presenting with hemorrhage: a case report. J Cerebrovasc Endovasc Neurosurg 14(4):305–308. https://doi.org/10.7461/jcen.2012.14.4.305From NLM PubMed-not-MEDLINE
57. Li J, Gao Z, Zhi X, Du J, Zhang H, Ling F (2018) Clipping of a Pediatric Pial Arteriovenous Fistula located at basilar artery tip using a hybrid trapping-evacuation technique. World Neurosurg 117:292–297. https://doi.org/10.1016/j.wneu.2018.05.110From NLM Medline
58. Li J, Yu J, Zhang H, Li G (2022) Inherited Pial Arteriovenous Fistula in Capillary Malformation-Arteriovenous Malformation Family. Ann Neurol 91(4):575–577. https://doi.org/10.1002/ana.26316From NLM Medline
59. Limaye US, Siddhartha W, Shrivastav M, Anand S, Ghatge S (2004) Endovascular management of intracranial pial arteriovenous fistulas. Neurol India 52(1):87–90 From NLM Medline
60. Lo Presti A, Weil AG, Fallah A, Peterson EC, Niazi TN, Bhatia S (2015) Treatment of a cerebral pial arteriovenous fistula in a patient with sickle cell disease-related moyamoya syndrome: case report. J Neurosurg Pediatr 16(2):207–211. https://doi.org/10.3171/2014.12.PEDS14486From NLM Medline
61. Lv X, Jiang C, Li Y, Yang X, Wu Z (2010) Clinical outcomes of endovascular treatment for intracranial pial arteriovenous fistulas. World Neurosurg 73(4):385–390. https://doi.org/10.1016/j.wneu.2010.01.023From NLM Medline
62. Lylyk P, Chudyk J, Bleise C, Serna Candel C, Aguilar Perez M, Henkes H (2017) Endovascular occlusion of pial arteriovenous macrofistulae, using pCANvas1 and adenosine-induced asystole to control nBCA injection. Interv Neuroradiol 23(6):644–649 10.1177/1591019917720921 From NLM Medline
63. Madsen PJ, Lang SS, Pisapia JM, Storm PB, Hurst RW, Heuer GG (2013) An institutional series and literature review of pial arteriovenous fistulas in the pediatric population: clinical article. J Neurosurg Pediatr 12(4):344–350. https://doi.org/10.3171/2013.6.PEDS13110From NLM Medline
64. Maejima R, Ohshima T, Miyachi S, Matsuo N, Kawaguchi R, Takayasu M (2018) Neonatal intracranial pial arteriovenous fistula treated with endovascular embolization: a Case Report. World Neurosurg 118:261–264. https://doi.org/10.1016/j.wneu.2018.07.114From NLM Medline
65. Mahmoud M, Abdalla RN, Mohamed AH, Farid M (2018) Pial fistula in infancy: report of two cases and literature review with special emphasis on the ruptured group. Interv Neuroradiol 24(4):444–449 10.1177/1591019918763146 From NLM Medline
66. Miyamoto N, Naito I, Takatama S, Iwai T, Tomizawa S (2023) A case of craniocervical junction pial arteriovenous fistula causing postoperative medullary and spinal cord edema. J Stroke Cerebrovasc Dis 32(2):106852. https://doi.org/10.1016/j.jstrokecerebrovasdis.2022.106852From NLM Medline
67. Morales-Gomez JA, Garza-Oyervides VV, Arenas-Ruiz JA, Mercado-Flores M, Elizondo-Riojas CG, Boop FA, de Leon (2017) A. M. Hydrocephalus in a patient with an unruptured pial arteriovenous fistula: hydrodynamic considerations, endovascular treatment, and clinical course. J Neurosurg Pediatr 19(3):307–311. https://doi.org/10.3171/2016.9.PEDS16458From NLM Medline
68. Naik SS, Sudhir V, Arvinda HR, Radhakrishnan M, Rao GS (2015) Embolisation of pulmonary vasculature during endovascular therapy-a case report. Childs Nerv Syst 31(9):1607–1611. https://doi.org/10.1007/s00381-015-2732-4From NLM Medline
69. Nakiri GS, Abud TG, Oliveira RS, Santos AC, Machado HR, Abud DG (2010) Endovascular treatment of intracranial pial arteriovenous fistula. Arq Neuropsiquiatr 68(3):463–465. https://doi.org/10.1590/s0004-282x2010000300026 From NLM Medline
70. Nesbit GM, Barnwell SL (1998) The use of electrolytically detachable coils in treating high-flow arteriovenous fistulas. AJNR Am J Neuroradiol 19(8):1565–1569 From NLM Medline
71. Newman CB, Hu YC, McDougall CG, Albuquerque FC (2011) Balloon-assisted Onyx embolization of cerebral single-channel pial arteriovenous fistulas. J Neurosurg Pediatr 7(6):637–642. https://doi.org/10.3171/2011.4.PEDS10577From NLM Medline
72. Okazaki T, Sakamoto S, Ishii D, Oshita J, Matsushige T, Shinagawa K, Ichinose N, Matsuda S, Kurisu K (2019) A Pial Arteriovenous Fistula in Infancy as the presenting manifestation of Hereditary Hemorrhagic Telangiectasia. World Neurosurg 122:322–325. https://doi.org/10.1016/j.wneu.2018.10.146From NLM Medline
73. Paramasivam S, Toma N, Niimi Y, Berenstein A (2013) Development, clinical presentation and endovascular management of congenital intracranial pial arteriovenous fistulas. J Neurointerv Surg 5(3):184–190. https://doi.org/10.1136/neurintsurg-2011-010241From NLM Medline
74. Pedicelli A, Iacobucci M, Frassanito P, Lozupone E, Masselli G, Di Rocco C, Colosimo CP (2017) Prenatal diagnosis and multimodal neonatal treatment of a Rare Pial Arteriovenous Fistula: Case Report and Review of the literature. World Neurosurg 104:1050e1013–1050e1018. https://doi.org/10.1016/j.wneu.2017.05.121. From NLM Medline
75. Phelps RRL, Raygor KP, Amans MR, Gupta N, Abla AA (2021) Occult Brain Arteriovenous Malformation superimposed on a Pial Arteriovenous Fistula: Case Report. Pediatr Neurosurg 56(6):549–554 10.1159/000517889 From NLM Medline
76. Puccinelli F, Tran Dong M, Iacobucci M, Mazoit JX, Durand P, Tissieres P, Saliou G (2019) Embolization of cerebral

arteriovenous shunts in infants weighing less than 5 kg. J Neurosurg Pediatr 1–9. DOI: 10.3171/2018.11.PEDS1865 From NLM Publisher.
77. Requejo F, Jaimovich R, Marelli J, Zuccaro G (2015) Intracranial pial fistulas in pediatric population. Clinical features and treatment modalities. Childs Nerv Syst 31(9):1509–1514. https://doi.org/10.1007/s00381-015-2778-3From NLM Medline
78. Requejo F, Teplisky D, Gonzalez Dutra ML, Lipsch J, Nguyen TN, Abdalkader M (2023) Intracranial arteriovenous shunts in infants: a decade of experience from a quaternary pediatric center. Interv Neuroradiol 15910199231180002. DOI: 10.1177/15910199231180002 From NLM Publisher.
79. Ryu B, Sato S, Mochizuki T, Inoue T, Okada Y, Niimi Y (2021) De novo intracranial arteriovenous malformation development after endovascular treatment for a pial arteriovenous fistula in capillary malformation-arteriovenous malformation syndrome. Interv Neuroradiol 27(1):25–30 10.1177/1591019920940515 From NLM Medline
80. Sabrina C, Laura M, Sabrina S, Giacomo T, Nicoletta M, Elena P, Francesco C, Eugenio B (2023) Expect the unexpected: a case of spontaneous thrombosis of a pial arteriovenous fistula in a preterm newborn with review of the literature. Childs Nerv Syst 39(3):793–799. https://doi.org/10.1007/s00381-022-05652-yFrom NLM Medline
81. Saliou G, Eyries M, Iacobucci M, Knebel JF, Waill MC, Coulet F, Ozanne A, Soubrier F (2017) Clinical and genetic findings in children with central nervous system arteriovenous fistulas. Ann Neurol 82(6):972–980. https://doi.org/10.1002/ana.25106From NLM Medline
82. Sarigecili E, Caglar E, Yildiz A, Okuyaz C (2019) A rare concurrence: gelastic seizures in a patient with right temporal nongalenic pial arteriovenous fistula. Childs Nerv Syst 35(6):1055–1058. https://doi.org/10.1007/s00381-019-04068-5From NLM Medline
83. Kenichi Sato ME, Kimiwada T, Tominaga T (2021) Venous varix enlargement after cerebrospinal fluid diversion in a neonate with pial arteriovenous fistula complicated with hydrocephalus. A case report. *Interdisciplinary Neurosurgery: Advanced Techniques and Case Management 23*. https://doi.org/10.1016/j.inat.2020.100981
84. Selvamurugan V, Prasad SN, Singh V, Neyaz Z (2021) Traumatic dissecting pathology of posterior cerebral artery: a report of two cases-aneurysm and pial arteriovenous fistula. BMJ Case Rep 14(5). https://doi.org/10.1136/bcr-2020-237722From NLM Medline
85. Smith AR, Carpenter J, Pergami P (2013) Nocturnal headaches and pulsatile cranial mass: the tip of an iceberg. Pediatr Neurol 49(5):358–360. https://doi.org/10.1016/j.pediatrneurol.2013.05.010From NLM Medline
86. Sugimoto T, Park YS, Nakagawa I, Nishimura F, Motoyama Y, Nakase H (2015) Effectiveness of intraoperative indocyanine green videoangiography in direct surgical treatment of pediatric intracranial pial arteriovenous fistula. J Neurosurg Pediatr 15(1):55–59. https://doi.org/10.3171/2014.9.PEDS13683 From NLM Medline
87. Tabatabai SA, Zadeh MZ, Habibi Z, Meybodi AT, Hashemi M (2008) Intracerebral atypical calcification in nongalenic pial arteriovenous fistula: a case report. Cases J 1(1):335. https://doi.org/10.1186/1757-1626-1-335From NLM PubMed-not-MEDLINE
88. Tomycz L, Maris AS, Ghiassi M, Singer RJ (2012) Open surgical disconnection for congenital, multi-hole, pial arteriovenous fistulae in non-eloquent cortex. Neurol India 60(4):415–418. https://doi.org/10.4103/0028-3886.100705From NLM Medline
89. Tripathy P, Sahoo RK, Sarangi GS, Mohanty S (2015) An intracranial arteriovenous fistula with a large pial venous varix in a young female: a case report and review of the literature. J Pediatr Neurosci 10(1):85–86. https://doi.org/10.4103/1817-1745.154372From NLM PubMed-not-MEDLINE
90. Venkatesulu K, Nandhakumar A, Cherian M, Mehta P, Palanisamy N (2019) Pediatric High-flow Pial Arteriovenous Fistula (AVF) for glue embolization: an anesthetic challenge. J Neurosurg Anesthesiol 31(2):262–263 1097/ANA.0000000000000480 From NLM Medline
91. Walcott BP, Smith ER, Scott RM, Orbach DB (2013) Pial arteriovenous fistulae in pediatric patients: associated syndromes and treatment outcome. J Neurointerv Surg 5(1):10–14. https://doi.org/10.1136/neurintsurg-2011-010168From NLM Medline
92. Wang YC, Wong HF, Yeh YS (2004) Intracranial pial arteriovenous fistulas with single-vein drainage. Report of three cases and review of the literature. J Neurosurg 100(2 Suppl Pediatrics):201–205. https://doi.org/10.3171/ped.2004.100.2.0201 From NLM Medline
93. Yan WT, Li XZ, Yan CX, Liu JC (2021) Typical subdural contrast effusion secondary to endovascular treatment of a pediatric pial arteriovenous fistula. Interv Neuroradiol 27(1):31–36 10.1177/1591019920938965 From NLM Medline
94. Ye M, Zhang P (2018) Transarterial balloon-assisted glue embolization of Pial Arteriovenous Fistulas. World Neurosurg 115:e761–e767. https://doi.org/10.1016/j.wneu.2018.04.171From NLM Medline
95. Yokota H, Yokoyama K, Uchiyama Y, Kinoshita S (2009) Cerebral pial arteriovenous fistula with associated varix treated by direct surgery. Neurol India 57(6):819–821. https://doi.org/10.4103/0028-3886.59493From NLM Medline
96. Zenteno M, Lee A, Satyarthee GD, Moscote-Salazar LR (2018) Endovascular Management of Intracranial Pial Arteriovenous Fistulas: experience of Largest Series at a single Center over six years. J Neurosci Rural Pract 9(3):406–409. https://doi.org/10.4103/jnrp.jnrp_455_17. From NLM PubMed-not-MEDLINE
97. Zhang Z, Yang K, Wang C, Zhang C, Xie X, Tang J (2013) Congenital pial arteriovenous fistula in the temporal region draining into cavernous sinus: a case report. Korean J Radiol 14(3):497–500. https://doi.org/10.3348/kjr.2013.14.3.497From NLM Medline
98. Zuccaro G, Arganaraz R, Villasante F, Ceciliano A (2010) Neurosurgical vascular malformations in children under 1 year of age. Childs Nerv Syst 26(10):1381–1394. https://doi.org/10.1007/s00381-010-1223-xFrom NLM Medline

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.