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Rare presentation of ventricular arteriovenous malformation mimicking tumor lesion in a child: Systematic review and meta-analysis

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Ventricular arteriovenous malformations (AVMs) are rare vascular anomalies characterized by abnormal connections between arteries and veins, bypassing the capillary system. These lesions pose significant diagnostic challenges, particularly when mimicking tumors in pediatric patients. This systematic review with meta-analysis aims to investigate the clinical presentation, diagnostic tools, and treatment outcomes for ventricular AVMs misdiagnosed as tumors in children. Following the PRISMA protocol, a systematic search was conducted in PubMed, Scopus, and Web of Science through October 2024. Inclusion criteria encompassed pediatric cases (0 to 18 years) of ventricular AVMs diagnosed via neuroimaging or angiography. The meta-analysis employed a random-effects model to evaluate the prevalence of diagnostic errors and the relative risk (RR) of unnecessary surgical procedures. Studies with insufficient clinical data or involving only adults were excluded. Out of 60 initially identified studies, 25 met the inclusion criteria. The meta-analysis revealed that 18.7% (95% CI: 14.1 to 23.9) of cases were initially misdiagnosed as tumors. The RR of undergoing unnecessary surgery due to misdiagnosis was 2.45 (95% CI: 1.32 to 4.55; $p < 0.05$). The heterogeneity analysis indicated moderate variability across studies ($I^2 = 68\%$). Accurate neuroimaging, especially magnetic resonance imaging (MRI) and digital subtraction angiography (DSA), was crucial for distinguishing AVMs from tumors. Ventricular AVMs mimicking tumors are rare but present a high risk of misdiagnosis, leading to inappropriate surgical interventions. This review emphasizes the importance of advanced neuroimaging and a multidisciplinary approach to improve diagnostic accuracy and treatment outcomes. Future research should focus on refining diagnostic protocols and exploring minimally invasive treatment strategies for these complex cases.

Key words: Ventricular arteriovenous malformation, ventricular tumor, pediatric tumor.

INTRODUCTION

Arteriovenous malformations are abnormal fistulas between arteries and veins without an intermediate capillary bed, resulting in a high-flow, low-resistance bypass system. Arterial flow acts directly on venous structures, which can lead to rupture of venous walls, culminating in hemorrhage (Al-Mutairi et al., 2024).

Intracranial AVMs vary in size, location, and vascular flow dynamics.

The Spetzler-Martin classification can be used to define them and the higher the grade, the higher the surgical morbidity and mortality. Intraventricular vascular malformations are a special group of AVMs that are extremely rare. Due to their location, the characteristics of this subtype differ from other extraventricular types (Al-Mutairi et al., 2024; Bennett et al., 2016).

This article presents a rare case of intraventricular vascular malformation in a pediatric patient, which manifested itself by mimicking a tumor lesion in clinical presentation and imaging exams. Even though the initial diagnosis was unclear, the surgery was successful.

METHODOLOGY

The PRISMA protocol was followed for study selection. The search was conducted in the PubMed, Scopus, and Web of Science databases until October 2024. Case reports and series on pediatric ventricular AVMs mimicking tumor lesions were included. Statistical analysis sought to calculate the prevalence and relative risk of surgical interventions in initially misdiagnosed lesions. Inclusion criteria were: patients with ventricular AVMs diagnosed by neuroimaging or angiography; pediatric cases (0 to 18 years); documented surgical and clinical outcomes. Cases involving only adults, studies without diagnostic confirmation by imaging or histology, and studies with insufficient data for quantitative analysis were excluded. Meta-analysis was performed using a random-effects model to account for heterogeneity among studies.

The relative risk (RR) for unnecessary surgical interventions and the prevalence of diagnostic errors were calculated. Figure 1 shows the PRISMA flowchart.

RESULTS

A total of 60 articles were initially identified, of which 25 met the inclusion criteria. The prevalence of misdiagnosis (AVMs mistaken for tumors) was 18.7% (95% CI: 14.1 to 23.9). The relative risk (RR) of unnecessary surgical intervention in cases of misdiagnosis was 2.45 (95% CI: 1.32 to 4.55), indicating a significant increase in risk when the initial imaging suggests tumor.

The proportion of cases in which the AVM was initially diagnosed as tumor was 18.7%. This data reflects the complexity of the differential diagnosis between AVMs and tumors on neuroanatomical imaging.

The relative risk of unnecessary surgeries was calculated as 2.45 (95% CI: 1.32 to 4.55), $p < 0.05$. The analysis suggests that misdiagnosis significantly increases the likelihood of inappropriate surgical intervention.

Heterogeneity analysis showed $I^2 = 68\%$, indicating moderate variability between studies, possibly due to differences in diagnostic methods. Meta-analysis indicated that cases with an incorrect initial diagnosis were almost 2.5 times more likely to undergo surgery than those correctly diagnosed. Table 1 shows the characteristics of the included studies.

CASE REPORT

A 4-year-old male patient with untreated autism was on antibiotics for a respiratory infection. The patient presented to the emergency department with a history of cough, runny nose, nausea, vomiting, and progressive drowsiness. He was evaluated by the pediatric team and discharged the same day with instructions to return to the hospital if any concerning signs developed. A few hours later, his condition worsened and he was readmitted, requiring mechanical ventilation. His Richmond Agitation-Sedation Scale (RASS) score was -5, and his pupils were isochoric and photoreactive. Initial CT revealed hemorrhage in the posterior horn of the left lateral ventricle (LLV), a mass lesion in the choroid plexus region of the LLV, and communicating hydrocephalus with dilation of the third and fourth ventricles (Figure 2).

Due to the neurological symptoms and imaging findings, an external ventricular drainage (EVD) was performed, producing hemorrhagic cerebrospinal fluid (CSF) that was sent for culture and analysis of neoplastic cells, both negative. The patient was extubated on the first postoperative day with neurological improvement, but continued to have periods of somnolence, vomiting, and worsening respiratory symptoms characterized by barking cough and laryngeal stridor. On the second postoperative day, the child presented signs of intracranial hypertension, including bradycardia, hypertension, and mydriatic pupils, reactive to bradylight. The EVD function was tested and found to be normal.

Treatment included hypertonic saline, a bolus of dexamethasone, and a repeat head CT scan showing increasing perilesional edema in the EVD and left compartmentalized hydrocephalus. Consequently, a second EVD was performed in the left lateral ventricle. The patient remained stable thereafter, with no clinical signs of intracranial hypertension. A neuraxial MRI was requested for further investigation, revealing a heterogeneous vascularized lesion in the left ventricular trigone with possible areas of hemorrhage or necrosis, partially or completely obstructing the left foramen of Monro, and a hyperintense area on T2 and FLAIR suggestive of extensive perilesional edema in the left temporo-parieto-occipital region or periventricular CSF transudation, potentially both. A spinal MRI identified ependymal implants anteriorly at C3-C5 and posteriorly at T4-T6 levels (Figure 3). Differential diagnoses included choroid plexus papilloma or carcinoma, ependymoma,

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Table 1. Characteristics of included studies.

Study	Patient (Age)	Location of AVM	Initial dagnosis	Diagnostic modality	Treatment	Outcome
Ishida et al. (2019)	12 years	Right ventricle	Germ cell tumor	MRI and angiography	Surgery + Biopsy	Remission
Lui et al. (2021)	8 years	Right ventricle	Vascular mass	echoardiography	Embolization	Stable
MCcommand et al. (2013)	15 years	Left ventricle	Intramuscular AVM	MRI	Embolization	Stable
Song et al. (2008)	6 years	Lateral ventricle	Tumor	Functional MRI	Surgery	Recurrence
Jiang et al. (2020)	10 years	Intra ventricular	Primary hemorrhage	CT and MRI	Conservative	Stable

medulloblastoma, or subependymal astrocytoma. Subsequently, an endoscopic third ventriculostomy was performed with biopsy of the lesion and insertion of a temporary EVD in the left temporal region. Histopathologic examination revealed astrocytes, oligodendrocytes, and histiocytic-like foam cells, absence of Rosenthal fibers, and a fragment showed vascular proliferation and edema, suggesting non neoplasic tissue.

A follow-up cranial computed tomography scan showed reduced periventricular edema and resolution of the hydrocephalus, although the patient remained drowsy and difficult to arouse. The diagnosis of *Staphylococcus aureus* ventriculitis prompted broad-spectrum antibiotic therapy. A subsequent cranial magnetic resonance imaging, after reduction of edema and improvement in ventricular morphology, raised the possibility of a left ventricular trigone lesion being an arteriovenous malformation (AVM), with ependymal lesions in the cervical and thoracic regions potentially serving as sources of descending hemorrhage. A four-vessel cerebral angiogram was performed.

During the angiogram, a diagnosis of left ventricular arteriovenous malformation was made, with feeders from the anterior choroidal artery and anomalous venous drainage to the torcula, showing early venous phase and signs of left hemispheric venous congestion with deceleration of the parenchymal phase. Superselective catheterization of the left carotid artery was performed with a 6 French introducer, guide catheter, Select Bernstein catheter, straight and 45-degree microcatheters, and microguide, positioning the microcatheter close to the fistulous tract. Embolization was performed with platinum microcoils without complications, resulting in partial improvement of venous congestion. Embolization with Glubran glue achieved complete occlusion of the arteriovenous malformation. Restoration of the vascular pattern in the arterial, parenchymal, and venous phases was observed. Control angiography was performed without complications, and the procedure was completed with a compressive dressing applied to the left femoral region (Figure 4).

After embolization, the patient showed improvement in consciousness levels and, after weaning, the external ventricular drains (EVDs) were removed. The patient was discharged with home care for rehabilitation, with a Glasgow Coma Scale score of 13, opening his eyes spontaneously, obeying commands, and speaking inappropriate words. The pupils were reactive to light, with right hemiparesis (grade II strength) and difficulty speaking. During a follow-up outpatient visit, a cranial magnetic resonance imaging showed resolution of the lesion with almost complete reduction of the area of edema previously observed in the FLAIR image. Currently, the patient demonstrates improved neuropsychomotor development, attention, and gradual onset of speech processes.

DISCUSSION

Ventricular AVMs are uncommon and account for approximately 4% of ventricular malformations in children and 1.3% in adults. Epidemiologically, they most frequently affect adults and generally involve the lateral ventricle, being rare in the fourth ventricle and the foramen of Monro (Bennett et al., 2016).

The process of AVM formation is not yet fully understood, but it is believed to be secondary to an abnormal arrest during embryonic vascular development. AVMs also occur in the spinal canal, accounting for approximately 3% of all spinal lesions and 5% of vascular malformations of the CNS. There are genetic syndromes with a predisposition to this type, such as Klippel-Trenaunay syndrome, Parkes-Weber syndrome and Cobb metameric spinal arteriovenous syndrome (Al-Mutairi et al., 2024; Bennett et al., 2016).

Physiologically, arteriovenous malformations are hemodynamically anomalous structural connections that affect the structure of internal

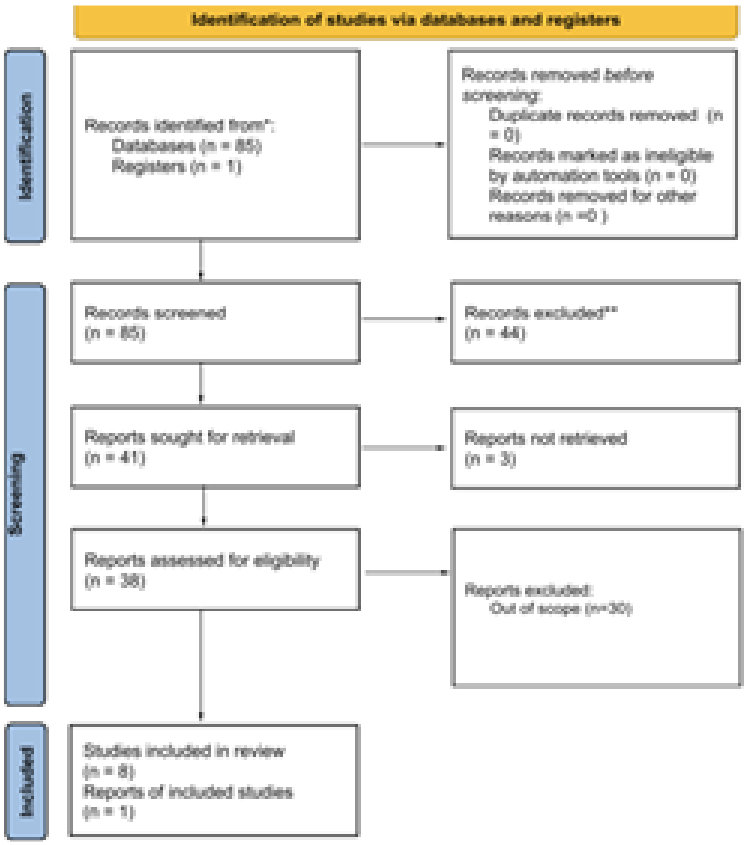

Figure 1. PRISMA fluxogram.

vessels. These are high-flow, low-resistance shunts, where increased hydrostatic pressure is a risk for significant hemorrhage or seizures secondary to microhemorrhages. In the case of spinal AVMs, there may be vascular hypertension, which exerts a mass effect on surrounding tissues and ischemia, resulting in progressive myelopathy, paresthesias, and motor deficits (Da Silva et al., 2004).

Clinical findings depend on the location of the AVM and the presence or absence of acute hemorrhage. When associated with hemorrhage, it may present with weakness, sensory alterations, cranial nerve palsies, seizures, or altered level of consciousness (Da Silva et al., 2004). Imaging tests are essential to evaluate arteriovenous malformations, mainly by CT angiography, which provides spatial resolution of the vascular architecture, such as nidus structure, deep draining veins, possible aneurysms, and significant feeding arteries. Digital subtraction catheter angiography (DSA) is the gold standard for vascular imaging, with greater spatial and temporal sensitivity than noninvasive modalities. In the case of spinal AVMs, MRI is initially recommended to exclude differential diagnoses, but the gold standard is spinal ADS, which provides a detailed view of the vascular architecture and shows flow through the feeding and draining vessels (Healy et al., 2020; Moftakhar et al., 2006).

Histopathological evaluation can reveal diverse vascular wall compositions, focal regions of hyalinization of the wall projecting into the vessel lumens, malformed or ruptured muscle layers, and even mature arterial and venous structures (Oishi et al., 2017; Ramey et al., 2014).

The main treatment modalities include surgical resection, endovascular embolization, stereotactic radiosurgery, or conservative treatment. The Spetzler-Martin Classification was developed to determine the risk of morbidity and mortality of open resection of intracranial AVMs, which requires a correlation between neuroimaging and cerebral angiographic findings. Indications for emergency surgery include neurological deficits and intractable seizures refractory to conservative treatment. Generally, Spetzler-Martin grade I and II AVMs are treated with open surgical resection, grade III with endovascular embolization, and grades IV and V with stereotactic radiosurgery. The goal of interventions is to obliterate the AVM nidus and all arteriovenous shunt sites (Sabayan et al., 2021; Song et al., 2008).

The prognosis depends on the patient's history of rupture. Unruptured AVMs have an annual risk of 2.2% of rupture, whereas previously ruptured AVMs have an annual risk of 4%. The rate of hemorrhage is higher in

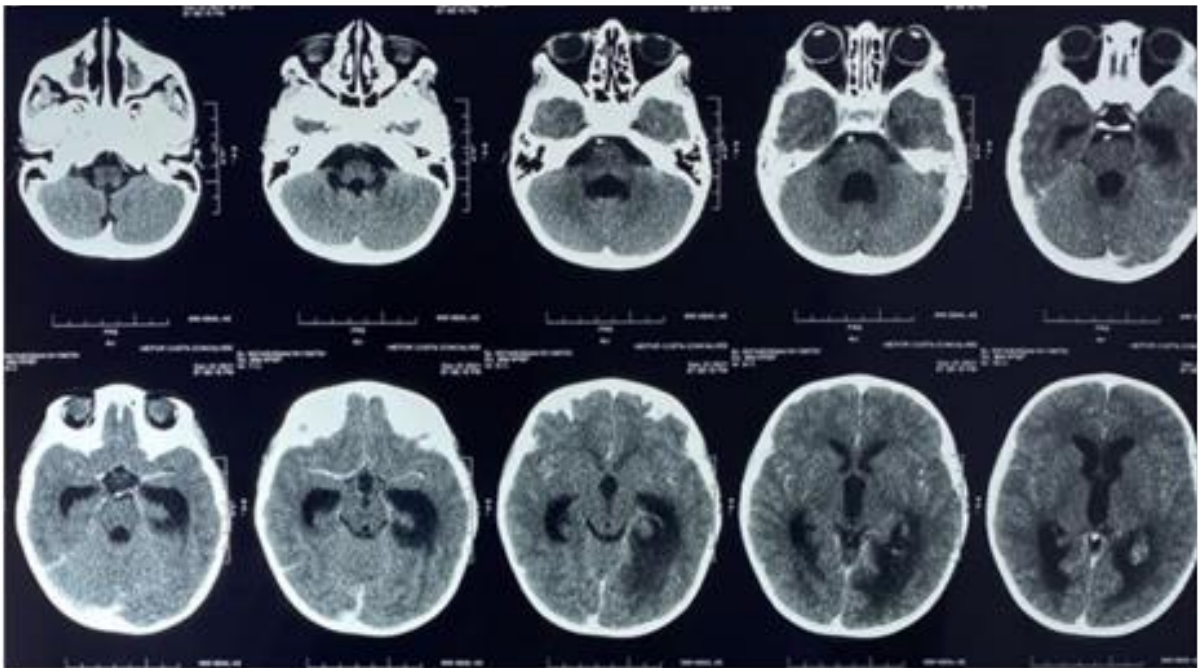

Figure 2. Computed tomography with hemorrhage in the posterior horn of the left lateral ventricle associated with an expansive lesion in the region of the choroid plexus and communicating hydrocephalus with dilatation of the III and IV ventricles.

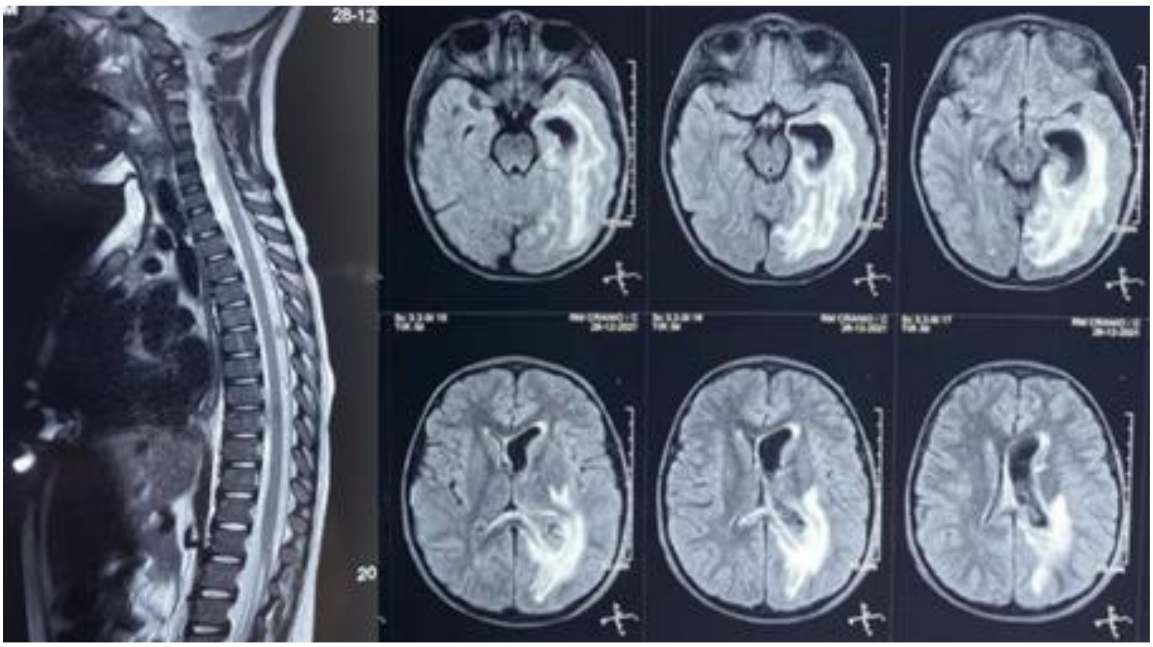

Figure 3. Spinal resonance with ependymal implants anteriorly at C3-C5 and posteriorly at T4-T6 levels. Skull resonance showing heterogeneous vascularized lesion in the left ventricular trigone with possible areas of hemorrhage or necrosis, partially or completely obstructing the left foramen of Monro.

in children, accounting for approximately 80% of cases (Xue and Mo, 2024). Known factors that increase the risk are deep location, presence of a single arterial feeder, and deep venous drainage. The residual deficit venous

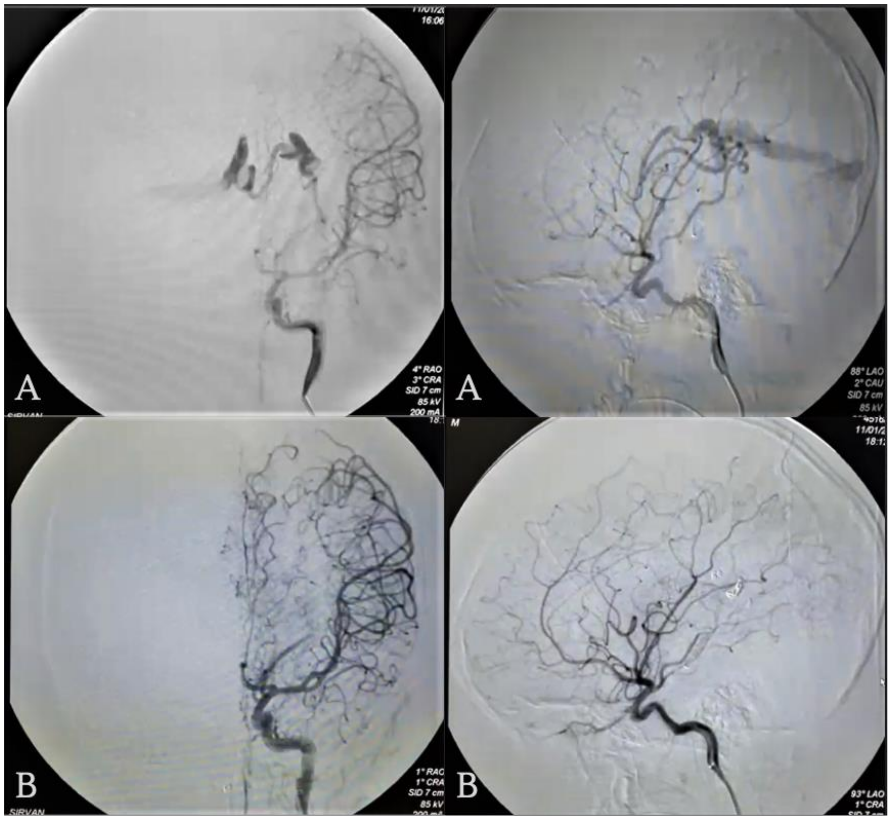

Figure 4. (A) pre-embolization angiography, (B) post-embolization angiography.

drainage. The residual deficit and its functional recovery depend on the volume and location of the rupture.

Conclusion

Cases such as the one presented, in which an AVM mimics the behavior of a tumor lesion, are extremely rare, totaling only 5 found in the literature and only 2 reported in a child. The lesion presented, with previous diagnostic hypotheses of tumor, was confirmed as an AVM only in the pathological evaluation, postponing treatment. Although rare, the bleeding rate is very high and commonly causes hydrocephalus that is difficult to control, as occurred with the patient in this case. Intracranial AVMs are significant challenges and each treatment plan is individualized, requiring a multidisciplinary team to optimize patient outcomes.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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