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Cerebral Pseudoaneurysms: A review of the current literature

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Abstract

Cerebral pseudoaneurysms are focal dilatations of an artery that involve all three layers of the vessel wall, unlike true aneurysms. They typically arise after trauma, iatrogenic (ventricular drain insertion, transsphenoidal surgery, etc.), or infections. Common presentations include headache, subarachnoid hemorrhage, or focal neurological deficits depending on the location and size of the pseudoaneurysm. Diagnosis often involves imaging techniques such as computed tomography angiography (CTA) or magnetic resonance angiography (MRA). Treatment options vary depending on the size, location, and clinical presentation and may include conservative observation, endovascular embolization, or surgical intervention.

Keywords: Pseudoaneurysm; Aneurysm; Stroke; Cerebrovascular; Endovascular; Microsurgery

1. Introduction

Cerebral pseudoaneurysms are vascular lesions that have a bulging shape but are different from true aneurysms. They account for only about 1% of all cerebral aneurysms, and the mortality rate associated with vascular defects was as high as 31-54% before treatment [1-3]. The true incidence, pathomechanism, and epidemiology of cerebral pseudoaneurysm are currently unknown. The vascular trauma leading to pseudoaneurysm formation could be caused by head trauma, iatrogenesis, and infection. The clinical manifestation varies with where the pseudoaneurysm arises and the status of rupture. Patients with cerebral pseudoaneurysms may be presenting with epistaxis, intracerebral hemorrhage (ICH), headaches, neurological deficits, and seizures [2-5]. The diagnosis can be made promptly with CTA or MRA, with digital subtraction angiography (DSA) as the gold standard, with treatment heavily depending on the site and morphological aspect of the pseudoaneurysm.

2. Methods

The study is a review of the literature. PubMed and Google Scholar were used to screen for literature. The following meshwork of words was used individually or in combination: cerebral, intracranial, pseudoaneurysm, symptoms, etiology, risk factors, pathophysiology, epidemiology, diagnosis, and treatment. Due to the lack of studies available, only observational studies and case reports were included in the criteria. While the years of publications range from 2014 until 2024. Only studies published in English were included.

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3. Results and Discussion

A pseudoaneurysm, also known as a false aneurysm, is generally defined as an abnormal vascular bulging due to an arterial defect caused by trauma, surgery, and infection. This type of vascular defect is specifically characterized by the involvement of the entire arterial wall layers, usually resulting from a hematoma between the external outer wall of the artery and the surrounding perivascular tissue, in connection with the injured artery [2][5]. In comparison, a true aneurysm will have all of the arterial wall layers intact [3].

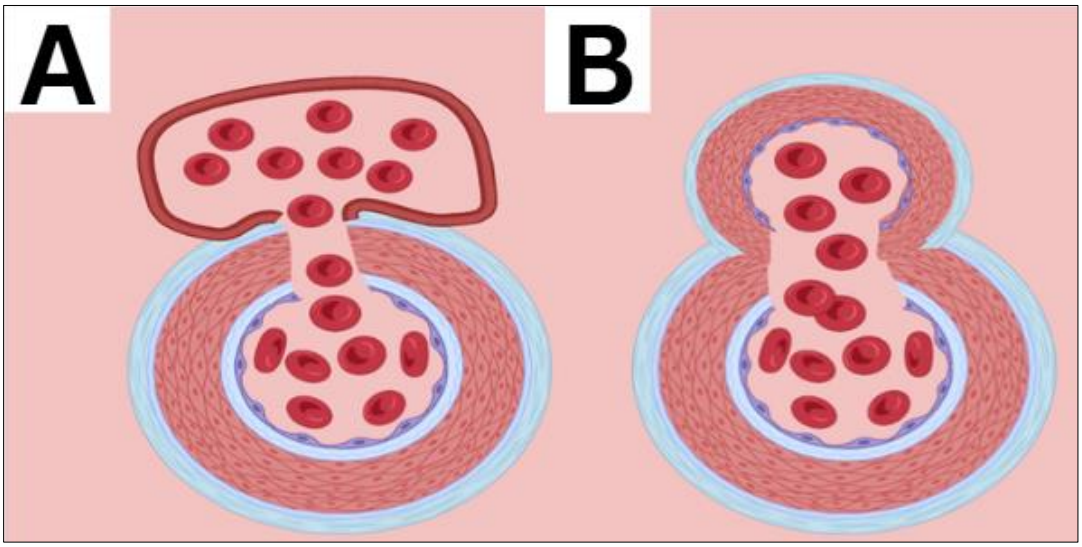

Figure 1 Illustration of pseudoaneurysm (A) and true aneurysm (B)

The clinical symptoms of a cerebral pseudoaneurysm can vary depending on its size, location in the brain, and rate of expansion. Enlarging cerebral pseudoaneurysms could have a pressing effect leading to clinical manifestations involving the surrounding brain structures. Common symptoms include epistaxis, seizures, and neurological deficits [2, 6-9]. Rupture of a pseudoaneurysm, particularly one involving the internal carotid artery (ICA), can result in subarachnoid hemorrhage (SAH), where blood leaks into the subarachnoid space surrounding the brain, causing a sudden & severe headache, often described as a thunderclap headache. Other symptoms that may occur are neck rigidity, paralysis, decreased mental state, or decreased consciousness [2,6,10]. In addition to ICA, a pseudoaneurysm with an underlying traumatic etiology also frequently occurs in the anterior cerebral artery (ACA) [11].

Table 1 Difference of pseudoaneurysm and aneurysm

Aspect	Aneurysm	Pseudoaneurysm
Involvement of arterial wall	All three layers (intima, media, adventitia)	Only one or two layers of the arterial wall
Incidence, epidemiology, and etiology	More common; associated with atherosclerosis, hypertension, genetic factors	Less common; often iatrogenic, traumatic, or mycotic
Risk of rupture	Variable, depends on size, location, and other factors	Generally higher than true aneurysms, especially if large or rapidly expanding
Treatment	Depends on size, location, and risk of rupture; options include observation, medication, endovascular coiling, or surgery	Treatment depends on size, location, and symptoms; options include observation, ultrasound-guided thrombin injection, compression, or surgical repair
Mortality & morbidity	Rupture can lead to stroke, subarachnoid hemorrhage, or death; other complications include thrombosis or embolization	Risk of rupture, thrombosis, infection, and compression of surrounding structures

There are several etiologies related to the formation of cerebral pseudoaneurysms. The most common cause is head trauma resulting in direct or indirect vascular trauma, which occurs more likely in males of young age [3,12-14]. Traumatic pseudoaneurysms may grow in size progressively, bringing about a high risk of rupture [5][8][11]. Surgical procedure is also one of the causes of pseudoaneurysms. This type of vascular lesion is named iatrogenic pseudoaneurysms. One of the most frequent procedures related to the development of pseudoaneurysms is notably the transsphenoidal approach to pituitary adenoma resection [6,10,15-18].

Pseudoaneurysms can also have infectious etiology. Various microorganisms could have been implicated in mycotic pseudoaneurysm formation, but the main organisms responsible are Staphylococcus aureus and the viridans group streptococci [7]. The risk of developing mycotic pseudoaneurysms increases significantly in patients with immunocompromised conditions, such as patients with HIV, cancer, diabetes, and chemotherapy.

Rapid diagnosis of cerebral pseudoaneurysms can be done by head and neck CTA owing to its simplicity, which is relatively comparable to MRA and DSA. MRA, on the other hand, could offer a better resolution to identify smaller vascular lesions. While they could be useful in identifying these vascular lesions, they have limited sensitivity compared to DSA. Thus, DSA is still regarded as the gold standard of diagnosis [8, 11, 19]. Doppler ultrasound helps assess blood flow and the size of the pseudoaneurysm, while angiography offers a more detailed map of the vessel anatomy and any potential risks, such as rupture or associated vascular abnormalities. Early and accurate diagnosis is critical for guiding treatment, which may range from conservative management in smaller, stable pseudoaneurysms to more invasive approaches, such as endovascular embolization or microsurgery, in cases with a higher risk of rupture.

In many regions, endovascular treatment is the first-line treatment of pseudoaneurysms that involves the use of coil embolization or flow-diverting stents [6, 9, 15-18]. This procedure aims to block blood flow into the pseudoaneurysm, allowing it to thrombose and preventing further expansion or rupture. Endovascular therapy is minimally invasive relative to surgical intervention and is associated with rapid recovery and low rates of complications [9, 20-22]. A variety of endovascular adjunctive treatments are available. Balloon-assisted coiling, stent-assisted coiling, and other adjunctive methods could help physicians treat pseudoaneurysms, especially in cases of wide-neck lesions.

Surgical treatment becomes necessary when endovascular therapy has failed or when the pseudoaneurysm ruptures to form edema [10-12]. In such cases, clipping or bypass surgery may be preferable. These microsurgical procedures aim to isolate the pseudoaneurysm from circulation and restore normal blood flow to the surrounding brain tissue [5,8,11-12]. During clipping, a metal clip is placed at the neck of the pseudoaneurysm, cutting off blood flow and preventing further expansion or rupture [11-12]. However, the notion that direct clipping is enough to treat pseudoaneurysms might be inaccurate and could lead to a fatal outcome. The lack of a true vessel wall could make pseudoaneurysm clipping lead to intraoperative bleeding or delayed pseudoaneurysm avulsion [2,10, 18].

Other treatment options are available alternatively. Pseudoaneurysm wrapping might be an effective solution when operating against lesions that are not amenable to direct clipping. This procedure involves circumferentially wrapping or coating intracranial aneurysms with diverse organic and non-organic material options. Thus, combining pseudoaneurysm wrapping by clipping might be a more feasible option to support the fragile pseudoaneurysm wall and maintain parent artery connectivity [12,18,21-22]. Alternatively, bypass surgery creates a new vascular connection to reroute blood flow around the affected area, thus preventing blood from flowing into the pseudoaneurysm. While this approach can be more complex, it ensures blood supply to critical brain regions while excluding the pseudoaneurysm from circulation. Surgical intervention carries higher risks due to its invasive nature, yet it offers a definitive solution when endovascular treatments are not feasible or have proven unsuccessful [5,21-22].

4. Conclusion

In conclusion, cerebral pseudoaneurysms are rare but potentially life-threatening complications arising from various etiologies. Accurate diagnosis through imaging techniques like CTA and MRA is crucial for appropriate management. Treatment strategies vary depending on the size, location, and clinical presentation of the pseudoaneurysm and may include conservative observation, endovascular embolization, or surgical intervention. Continued research and advancements in treatment modalities are essential to improve outcomes for patients with this condition.

Compliance with ethical standards

Disclosure of conflict of interest

To ensure transparency, the authors declare that they have no conflicts of interest, financial or otherwise, that could have influenced the conduct, analysis, or interpretation of this research. All the authors contribute equally to writing this literature review

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