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CEREBRAL ANEURYSMS: THERAPEUTIC STRATEGIES

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Abstract: Intracranial aneurysms (IAs) are arterial dilations whose rupture causes subarachnoid hemorrhage, an event with high morbidity and mortality. Treatment aims to exclude the aneurysm from circulation while preserving the parent vessel. This narrative review addresses the main therapeutic strategies, divided into two categories: microsurgery and endovascular therapy. Microsurgical clipping, the conventional method, offers high rates of durable occlusion but is more invasive. Endovascular therapy, which has become the first line of treatment in many centers, has evolved exponentially. It began with platinum coil embolization (coiling), which was improved by balloon-assisted techniques and stents to treat wide-neck aneurysms. A paradigm shift occurred with flow diverters, which reconstruct the parent artery, and intrasacculary flow disruptors (such as the WEB device), which induce thrombosis within the aneurysmal sac. Recent innovations include specialized stents for bifurcations (PulseRider) and the introduction of robotics in neurointervention, which promises greater precision and safety. The choice of therapeutic modality is complex, individualized, and depends on the characteristics of the aneurysm, the patient, and the experience of the team.

Keywords: Intracranial Aneurysm; Endovascular Therapy; Microsurgical Clipping; Flow Diverters; Coil Embolization; Subarachnoid Hemorrhage; Neurointervention.

INTRODUCTION

Intracranial aneurysms (IA) are abnormal dilations of the cerebral arterial walls, with an estimated prevalence in the general population that can reach up to 8% (Lee et al., 2022; Shen et al., 2025). Although most of these lesions remain asymptomatic, their rupture has catastrophic consequences, being the leading cause of non-traumatic subarachnoid hemorrhage (SAH), an event associated with high morbidity and mortality rates (Lee et al., 2022; Pontes et al., 2021). The fundamental principle in the management of IAAs is the complete exclusion of the aneurysmal sac from circulation, preserving blood flow in the parent vessels, branches, and adjacent perforating vessels (Lee et al., 2022).

Historically, the gold standard treatment has been microsurgical clipping, an established technique that has evolved significantly over the decades (Lee et al., 2022). However, the therapeutic landscape has been transformed with the advent and consolidation of endovascular therapies, which offer less invasive approaches and have become the first line of treatment in many centers (Pontes et al., 2021). Technological advances in this area have been exponential, starting with platinum coil embolization (coiling) and progressing to balloon- or stent-assisted techniques, to the development of more complex devices such as flow diverters and intrasacral flow disruptors (Lee et al., 2022; Shen et al., 2025).

The decision on the ideal therapeutic modality is a complex and individualized process that depends on a careful analysis of multiple factors, including patient characteristics, aneurysm morphology and location, and the experience of the multidisciplinary team (Lee et al., 2022). Given the diversity of options available, this review aims to synthesize and discuss the main therapeutic strategies for the management of intracranial aneurysms, covering everything from established techniques to the latest innovations.

METHODOLOGY

This study is a narrative review of the literature, designed to consolidate and examine current scientific publications on therapeutic strategies for intracranial aneurysms. The bibliographic search was performed in the PubMed database, using the descriptors "Intracranial Aneurysm" and "Treatment." These terms, aligned with the Medical Subject Headings (MeSH) terminology, were associated with the Boolean operators AND and OR to refine the search. The inclusion criteria covered articles with full text available, published in the last five years in English or Portuguese, and that directly addressed the proposed theme. Studies without a direct correlation with the scope of the study, duplicate articles, reviews with low methodological quality, and publications not indexed in the selected database were excluded. The article selection process took place in two phases: initial analysis of titles and abstracts, followed by a full reading of the texts to verify their relevance. The relevant data were then extracted and compiled in a descriptive manner.

RESULTS AND DISCUSSION

Treatment strategies for intracranial aneurysms fall into two main categories: the microsurgical approach and endovascular therapy, each with an arsenal of constantly evolving techniques (Lee et al., 2022). The choice between these modalities is influenced by a multifactorial analysis, although high-quality evidence directly comparing treatments remains limited, reinforcing the need for individualized decisions (Pontes et al., 2021).

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Microsurgical clipping is the conventional surgical method, which consists of obliterating the neck of the aneurysm with a metal clip through a craniotomy (Lee et al., 2022). It allows blood drainage in case of aneurysm rupture during the procedure and prevents intracranial hypertension (Pontes, 2021). This technique offers high rates of complete occlusion and durability, being particularly advantageous for middle cerebral artery (MCA) aneurysms, lesions with associated intracerebral hematoma that require evacuation, and in young patients with long life expectancy (Lee et al., 2022; Pontes et al., 2021). Despite its effectiveness, clipping is associated with longer hospital stays and an increased risk of perioperative neurological deficits when compared to endovascular techniques (Pontes et al., 2021).

The field of endovascular therapy has revolutionized the treatment of IAs, beginning with embolization with detachable platinum coils (coiling). This method seeks to fill the aneurysm , inducing thrombosis and isolating it from circulation (Lee et al., 2022). Although effective for narrow-neck aneurysms, simple coiling has limitations in wide-neck aneurysms due to the risk of protrusion and compaction of the coils, leading to recurrence rates that may require retreatment and follow-up (Lee et al., 2022). To overcome this limitation, adjuvant techniques have been developed. The balloon-assisted coiling (BAC) technique uses a balloon temporarily inflated in the parent vessel to contain the coils during their insertion (Lee et al., 2022). A more definitive solution is stent-assisted coiling (SAC), in which a stent is positioned through the neck of the aneurysm, creating a scaffold that prevents spring coils from herniating and promotes endothelialization (Lee et al., 2022). The use of stents, however, requires dual antiplatelet therapy to mitigate the risk of thromboembolic events (Lee et al., 2022).

For wide-neck bifurcation aneurysms, innovative devices such as PulseRider have emerged, a self-expanding stent that provides support to the aneurysmal neck without excessively covering the branch arteries, with the aim of preserving luminal patency and hemodynamic flow in the vado (Lee, 2022), demonstrating adequate occlusion rates greater than 90% at six months, with a favorable safety profile and efficacy (Pranata et al., 2021). Another device that facilitates the treatment of wide-neck intracranial aneurysms is the Woven EndoBridge device (Pranata et al., 2021). There are devices that function as flow diverters, whose function is to alter the flow of the internal coronary artery (ICA) by adding a stent-like mesh along the artery. The flow diverter can create stasis in the IA for the formation of thrombi that regress, resulting in remodeling. They are important in situations of wide, giant, or fusiform necks (Lee, 2022). Another class of devices are intrasacular flow disruptors, such as the Woven EndoBridge (WEB), implanted within the aneurysm to slow down flow and induce thrombosis (Lee et al., 2022; Sahnoun et al., 2022). In cases of WEB device protrusion, combination with an adjacent stent has been shown to be a safe and effective strategy, achieving complete occlusion in more than 90% of cases at 12 months, without increased morbidity and mortality (Sahnoun et al., 2022).

A paradigm shift occurred with flow diverters (FDs), which act to reconstruct the parent artery rather than occlude the aneurysmal sac (Lee et al., 2022). These dense metal mesh devices are implanted in the vessel of origin, diverting blood flow from the aneurysm, which leads to its gradual thrombosis and the formation of a new endothelial layer over the device (Shen et al., 2025). FDs are especially indicated for giant, fusiform, or wide-neck aneurysms in the ophthalmic and cavernous carotid segments (Lee et al., 2022). The long-term success of this technique depends on reendothelialization, a biological process in which Endothelial Progenitor Cells (EPCs) play a crucial role, migrating to the site of injury and differentiating to restore vascular integrity (Shen et al., 2025).

Continuous innovation is also reflected in the introduction of robotics in neurointervention. The use of robotic systems, such as CorPath GRX, for the treatment of IAs has proven to be feasible and safe, allowing precise control over microcatheters, guidewires, and stents, with the potential to reduce operator radiation exposure and, in the future, enable remote procedures (Cancelliere et al., 2022). One-year follow-up results in patients treated with robotic-assisted showed stable and complete occlusion in most cases, confirming the effectiveness of the technology (Cancelliere et al., 2022).

CONCLUSION

The treatment of intracranial aneurysms has been transformed by rapid technological advances, shifting from a predominantly microsurgical approach to an era dominated by minimally invasive endovascular techniques. Clip placement remains valuable for specific cases, but the endovascular arsenal—which has evolved from simple coiling to advanced devices such as flow diverters and intrasacral flow disruptors—has dramatically expanded the ability to treat complex aneurysms safely and effectively. This evolution reflects a paradigm shift, focusing not only on occlusion of the aneurysmal sac, but also on reconstruction of the parent artery. The incorporation of emerging technologies, such as robotics, signals a future with even more precise procedures. It can be concluded that the current approach is multifaceted and highly individualized, requiring careful analysis to select the best strategy from a sophisticated and constantly expanding range of therapeutic options.

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