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A Doughnut in the Brain: an overview of the pathophysiology and the current treatment options for intracranial doughnut-shape aneurysm

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Giant aneurysms, those larger than 25 mm in diameter, are relatively uncommon and are often accompanied by thrombosis (1). Doughnut-shaped aneurysms are giant round-shaped aneurysms composed of an intraluminal thrombus and marginal parent arteries (2). Doughnut-shaped aneurysms are rare subtype of partially thrombosed giant aneurysms and account for ≤1% of large/giant aneurysms (2,3).

Pathophysiology:

The Doughnut-shaped aneurysms formed when the aneurysm geometry and flow conditions result in circular laminar flow (4). This type of aneurysm constitutes of 3 parts: the inflow artery, outflow artery and a central thrombosed part which is already excluded from circulation.

Disruption of flow (slow flow) within the aneurysm results in progressive thrombosis and exclusion from the intracranial circulation (5).

Horowitz et al. described a mathematical model showing the intraluminal pressure changes that might be expected following outflow occlusion (6). They reported that the resulting variations in pressure should be less than those induced by normal daily activities and concluded that outflow occlusion would not be expected to increase the risk of an aneurysm rupture (1).

On imaging, Rooij et al describe the 'donut sign' on angiography, with the central filling defect which is the doughnut hole represent the intraluminal thrombus and is responsible for the donut-shaped appearance seen at angiography (4).

Treatment options:

Optimal management of giant doughnut-shaped aneurysms has not yet been established. In contrast to the usual saccular aneurysm, giant doughnut-shaped aneurysms have separate inflow and outflow vessels; therefore, clipping the aneurysmal neck is unsuitable (1). Given its rarity and unusual appearance, the best treatment approach for this type of aneurysm has not been well established (5).

The treatment options include: 1. complete obliteration of the aneurysm lumen with or without resection (7). 2. Outflow occlusion with distal revascularization (1). 3. Proximal occlusion (8). 4. Endovascular coil embolization (5). 5. Endovascular flow diversion (5).

Although complete obliteration of the aneurysm lumen with or without resection is an ideal treatment for such complex aneurysms, for some cases, it is difficult to achieve trapping and distal revascularization during surgery (7).

Outflow occlusion with distal revascularization could be an effective surgical option for such a unique aneurysm. For some cases, trapping of the involved segment with or without distal bypass is recommended (1,6). Bypass surgery to treat distal ACA aneurysms can be categorized as intracranial–intracranial (IC–IC) and extracranial–intracranial (EC–IC) types. IC–IC bypasses include in situ bypass, reanastomosis, reimplantation, and bypass with graft placement. IC–IC bypass has several advantages. IC–IC bypass could provide enough hemodynamics to the target region without additional blood flow (1).

Furthermore, IC–IC bypass do not require secondary incision and graft harvest. However, IC–IC bypass also has disadvantages. This maneuver is technically challenging in the narrow and deep working space in the interhemispheric fissure. In addition, if a bypass fails and occludes, both distal arterial territories could develop serious ischemia (1).

Proximal occlusion is also considered to be suitable for cases with surgical difficulty of trapping because proximal occlusion for aneurysms is believed to reduce the hemodynamic burden of the aneurysm, promote complete thrombosis in the aneurysm sac, and reduce the size of the aneurysm (8). Recently, endovascular treatment has shown good results for large and giant aneurysms. However, the usefulness of coil embolization for partially thrombosed giant aneurysms remains controversial because of coil compaction and/or migration into the thrombus (1).

Endovascular coil embolization is typical for some cases but the technical difficulty limits its application in most of the circumstances (5).

Endovascular flow diversion has been shown to be an effective alternative to coil embolization of intracranial aneurysms (5). However, while effective in treating intracranial aneurysms, flow diverter stents are associated with procedure- related complications (9).

Partially thrombosed aneurysms in particular have a high recurrence rate of up to 75%, with larger aneurysms having a worse prognosis (10). Limited published experience with donut aneurysms suggests they are also prone to recurrence (4).

Conclusion

The treatment of partially thrombosed giant (doughnut) aneurysm is critical and should be individualized case by case putting in mind the above surgical and endovascular options.

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