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Letter to the Editor

Distal middle cerebral artery aneurysms: What non-neurosurgeons need to know

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Dear Editor,

INTRODUCTION

Middle cerebral artery (MCA) aneurysms comprise 18–40% of all intracranial aneurysms and are classified into proximal, bifurcation, and distal types based on their location on MCA. Distal MCA aneurysms are a rare presentation, constituting only 1–7% of all MCA aneurysms, and include the aneurysms located at the distal end of the MCA bifurcation and are classified into four segments: M2 (insular segment), M2-M3 junction, M3 (opercular segment), and M4 (cortical segment).[3]

Distal MCA aneurysms are usually deep-seated, with a narrow lumen, associated with anatomical variations, and the shape of the aneurysms (fusiform or dissecting) makes them more prone to complications. These characteristics of distal MCA aneurysms, besides the paucity of data concerning the best treatment modality, imaging techniques, and outcomes, make them a significant obstacle to treating surgeons.

The purpose of this paper is to shed light on some critical peculiarities of distal MCA aneurysms that may help pave the future road toward establishing consensus guidelines and management plans in the context of team-based and patient-centered approaches.

Etiology of the distal MCA aneurysms

Several etiologies have been described for aneurysms located in distal MCA. Traumatic aneurysms, including blunt head injury, missile injury, penetrating injury, and iatrogenic injury, are the most common etiology. In mycotic aneurysms, there is a source of infection that cannot always be determined, and the histopathological examination reveals the destruction of the vessel's walls and infection. The term "microbial aneurysm" was suggested rather than infectious or mycotic, as a wide variety of organisms can be the underlying cause.[5] Neoplastic distal MCA aneurysm is another etiology that should be considered in patients with concomitant metastatic cancer. The predilection of mycotic and neoplastic aneurysms for the distal branches can be explained by septic and tumor particle embolization, respectively.

When no identifiable cause exists, distal MCA aneurysms will be regarded as idiopathic. Thorough investigations, including histopathological examination, are necessary to rule out all other possibilities. Certain cases of distal MCA aneurysms are alleged to be idiopathic, based on a likely excluded traumatic and infectious cause, and there is still an alternative suggested probability. For instance, nonsignificant head trauma assumed radiotherapy-induced distal MCA aneurysm and the possibility of culprit vasculitis. Although some consider vasculitis as a separate etiological entity, inconsistent pathological findings should promote investigation for another overlooked etiology.[8] We think that idiopathic *per se* may be a favorable totalistic term, in which histopathology may be non-applicable, and as well, no other possibility can be found when it is non-traumatic and non-infectious. This is supported by some reviewers in their papers, who classify it as idiopathic, while others use the term "nontraumatic and non-infectious."[7,9]

Location of the distal MCA aneurysms

M3 segment

The M3 segment (opercular segment) is a transitional zone between the M2 trunks (superior and inferior) and the M4 cortical branches; therefore, it would be neither a single nor double trunk. In reality, it is comprised of twelve branches, equivalent to those of the M4 segment, and divided into superior (fronto-parietal) and inferior (temporo-occipital) groups.

These branches course through the Sylvian fissure, along the frontoparietal and temporal opercula, and once they exit, their segment name changes to M4. This would be of value in precise M3 segment aneurysm localization, in which the same upcoming rules used for M4 segment aneurysms can be applied.[6]

M4 segment

The M4 segment (cortical segment) commences from the superficial edge of the Sylvian fissure till branches terminate at the lateral cortical surface. The location of aneurysms at this segment is often left unspecified, which can be explained by the tremendous variations in these branches. For example, some of these branches may originate from common trunks, while others are early branches, and some can be absent or duplicated.[1]

M4 branches are distributed to all four cortical lobes: frontal, parietal, occipital, and temporal. Further, within each lobe, there are typically three M4 branches located at the anterior, middle, and posterior regions of that lobe. Using the relationship of the aneurysm to the brain's cortical lobes seems to be a promising way to identify the precise location of the cortical MCA aneurysms.

Shape of the distal MCA aneurysms

The morphology of distal MCA aneurysms can be exhibited as saccular and non-saccular (fusiform/dissecting) forms, with a higher rate of being non-saccular when compared to other cerebral aneurysms.[4] Cutting the blood supply is the most straightforward method of treating an aneurysm; this can be achieved easily in saccular aneurysms through surgical clipping. However, this might not be the case while dealing with fusiform/dissecting aneurysms, in which different techniques should be utilized, such as wrapping, trapping, or parent artery occlusion with bypass if needed.[4] Therefore, determining the distal MCA aneurysm shape would be of paramount importance in the choice of the most appropriate treatment strategy and, thus, the patient outcomes.

Rupture status of the distal MCA aneurysms

The ruptured distal MCA aneurysms are very rare, constituting only 0.47% of all cerebral aneurysms and 2% of MCA aneurysms.[10] These aneurysms are usually associated with poor prognosis due to a higher rate of coexistent intracerebral hemorrhage. The vast majority of ruptured distal MCA aneurysms are determined to be saccular, although fusiform aneurysm predominance was also reported.[2] The study reported that 44% of the ruptured distal MCA aneurysms were <7 mm in diameter, which makes the distal MCA aneurysms dangerous even in their small size. The reduced thickness and diameter of the distal branch arteries can explain this. In cases of ruptured distal MCA aneurysms, good clinical outcomes can be achieved through early intervention and hematoma evacuation during aneurysmal clipping or trapping. Intraoperative aneurysmal localization in the swollen brain can be difficult; therefore, neuronavigational techniques are recommended.

Associated aneurysms with the distal MCA aneurysms

Distal MCA aneurysms are more likely to be associated with other aneurysms, with 74% and 56% of unruptured and ruptured distal MCA aneurysms, respectively, associated with other aneurysms.[2] Despite this, there is no established consensus on how to manage the associated aneurysms. One of the suggested approaches is a surgical clipping of all aneurysms that can be exposed during the same craniotomy. This approach is not advised in the cases of ruptured distal MCA aneurysms with resultant brain swelling; therefore, finding a consensus management plan is demanding.

Presentations and clinical features of the distal MCA aneurysms

Distal MCA aneurysms can be mostly asymptomatic and discovered incidentally. Symptoms are usually attributed to the mass effect, which can present with nonspecific symptoms (e.g., headache), seizures, or neurological deficits. Clinical presentation can be more serious if the aneurysm ruptures, resulting in subarachnoid hemorrhage with or without intracerebral hemorrhage. The clinical presentations of distal MCA aneurysms are considered somewhat unpredictable due to the overlap in these presentations. The presentation of ruptured distal MCA aneurysms can be more dangerous than ruptured aneurysms at other sites due to the tendency of distal MCA aneurysms to present with intracerebral hemorrhage alongside the subarachnoid hemorrhage.

Treatment of distal MCA aneurysms

The treatment options for distal MCA aneurysms vary depending on the MCA segment. The M2 and M3 segment aneurysms are often managed in similar manners to the M1 segment aneurysms with coiling or surgical clipping unless it is irregular, fusiform, dissecting, or a pseudoaneurysm; then, it follows the management plan of the M4 segment aneurysms with a diversity of treatment options, mainly include conservative, endovascular, and surgical.

The conservative measures involve follow-up of the aneurysm with magnetic resonance angiography and/or computed tomographic angiography, and the use of antibiotics in case of mycotic aneurysms. The endovascular option involves sacrificing the parent vessel through embolization using coiling, onyx, or a combination of both. The surgical techniques may include parent vessel sacrifice through coagulation or trapping through aneurysm neck clipping and proximal occlusion. Other techniques are surgical clipping with or without wrapping and bypass, revascularization, or anastomosis with or without trapping or clipping. Examples of the later technique include bypass followed by parent vessel occlusion or clip trapping or clipping, excision alone or followed by end-to-end anastomosis or use of a graft. Several factors play a role in determining the more appropriate treatment technique for the M4 segment aneurysms; aneurysm size, shape, location, and etiology should be considered, as well as the presence of thrombosis and whether it is a pseudoaneurysm.[2] For instance, bypass followed by parent vessel occlusion and wrap clipping may be preferred strategies for fusiform and dissecting aneurysms. While in mycotic aneurysms, the wrapping technique is better to be avoided. In cases of more distal aneurysms and pseudoaneurysms lacking intact lumen, coiling will be surpassed by onyx embolization as the recommended treatment technique.

The fourth MCA segment branches aneurysms (proximal vs. distal)

The cortical branches, comprising the M4 segment, extend from the Sylvian fissure edge along the lateral cortical surface until branch termination. Each branch is divided into two sections: proximal and distal; the former section grows 2 cm peripherally from the emergence of the artery in the Sylvian fissure. The distal section extends up to the branch terminus, close to the superior or inferior border of the lateral surface of the cerebral cortex. This anatomical consideration guides a more precise localization of the cortical branches' aneurysms, which aids in the selection of a more suitable treatment technique.

For the proximal cortical branches' aneurysms, there is less potential for sacrificing the parent vessels and a greater likelihood of revascularization or anastomosis. On the other hand, for distal MCA aneurysms, the parent vessel can be sacrificed with impunity, either through microsurgical or endovascular means, unless they are located in eloquent areas.

Outcome measures of the distal MCA aneurysms

One important aspect of evaluating the postoperative outcomes of distal MCA aneurysms is the modified Rankin scale (mRS); scores 0–2 would represent good clinical outcomes, and scores 3–6 denote poor clinical outcomes. Moreover, it is also important to evaluate the seizure status of the patients who have already presented with seizure, as it is an unusual presentation of unruptured cerebral aneurysms. In that case, additional differentials should be added to the list. A decrease or absence of seizures postoperatively will support the aneurysm as the etiology. However, the persistence of seizures does not necessarily exclude the aneurysm; adjacent parenchymal gliosis may have resulted from repeated subclinical hemorrhages. The other significant aspect of outcome measures is the obliteration rate of the distal MCA aneurysms, which can be assessed using the Raymond-Roy occlusion classification scale: Complete obliteration is class I, residual neck is class II, and residual aneurysm is class III.

The composite outcome incorporating both clinical and obliteration measures would be more precise in the assessment of distal MCA aneurysm outcomes. As both measures are unidimensional, combining them will provide reliable results in the overall outcome of the patients. In such a way, patients with adequate composite outcomes, represented by good clinical outcomes (mRS ≤2) and complete aneurysmal obliteration (Raymond-Roy-I), are predicted to have better long-term functional outcomes and less likelihood of recurrence of symptoms.

SUMMARY

Although the main general characteristics of distal MCA aneurysms are well understood, there is still a gap regarding some clinical peculiarities that are worth knowing for non-neurosurgeons. The possible culprit etiologies in distal MCA aneurysms include trauma, mycotic source, neoplasm, or can be idiopathic. Regarding the anatomy, the M3 segment is divided into twelve branches; therefore, the exact location and supply of all M4 branches should also be applied to the M3 branches. In addition, the aneurysmal relationship with the brain lobes can be used to locate the M4 segment aneurysms more precisely. The presentation of the distal MCA aneurysms can vary from asymptomatic presentation to life-threatening intracerebral hemorrhage, depending on their rupture status. The shape of the aneurysm affects the aneurysm rupture risk and has an important role in deciding the most appropriate treatment modality. The distal MCA aneurysms are well known to be associated with other intracranial aneurysms; however, there is still no consensus management plan for those associated aneurysms. The treatment options and techniques for distal MCA aneurysms vary widely, and all the aforementioned aspects may guide the selection with subsequent reflection on patients' outcomes.

CONCLUSION

Distal MCA aneurysms have long been a topic worth discussing; further research exploring their hidden angles will aid in developing a standardized therapeutic approach with consequent major impacts on patients' lives.

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