Microsurgical Management of Thrombotic Aneurysms

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Introduction

A 'thrombotic aneurysm' is defined as the one having a solid organized intraluminal thrombus, diagnosed on the basis of preoperative CT/ or MRI, angiography and peroperative findings. Intra- aneurysmal thrombosis, either total or partial, is a well recognized entity, with a special propensity to occur as an epiphenomenon in giant aneurysms, but this has been underreported in the published literature, despite its grave implications from the point of view of neurosurgical management. This phenomenon was first reported in the literature by Lyell [1] while performing the autopsy of a patient who died of unrelated causes. These aneurysm subtypes have rarely been analyzed separately in the literature. In most of the series, they have been evaluated in association with giant, fusiform or dolichoectatic aneurysms.

Apart from several case reports documenting the clinical, radiological and surgical relevance of thrombosis in giant aneurysms [2-6], there are not many studies on the pathogenesis and management of intra- aneurysmal thrombosis in literature. Furthermore, there is much confusion in the literature regarding the management strategies in thrombosed aneurysms.

The purpose of this article is to understand the clinical significance of thrombosed aneurysms from the neurosurgical aspect and to review the management strategies used in the surgical treatment of these distinct lesions.

Pathogenesis of intraluminal thrombosis

Intra-aneurysmal thrombosis has been reported to occur in 50% of the cases of giant intracranial aneurysms [7-12]. According to Black and German [6], the most important mechanism contributing to the development of thrombosis, is the critical ratio between the aneurysmal volume and aneurysmal neck size, below which thrombosis frequently occurs. They demonstrated that the velocity of blood inside the aneurysm is inversly related to the volume of the aneurysm and the flow into the aneurysm is related to the neck size. Therefore, as the aneurysm starts to thrombose, the possibilty of further thromboses decreases further, and this dynamic balance depends on the hemodynamic properties of the parent vessel. Apart from this, several hemodynamic and biophysical parameters also contribute towards the development of intraaneurysmal thrombosis, which are of lesser relevance to the pathogenesis. Furthermore, the fluid dynamics of the jet stream of blood from the parent artery is altered by the effect of the aneurysm on the arterial lumen. Robertson et al [13] have previously postulated the 'Coanda effect' or the 'boundarywall effect', and stressed its importance in the development of adverse ischemic changes after aneurysm surgery. Recently, this effect has been found to be a major factor in the development of giant serpentine aneurysms [2].

Clinical Presentation

Majority of the thrombosed aneurysms present with symptoms of mass effect, as they are mostly associated with giant aneurysms. Although, 47% of patients with giant intracranial aneurysms may also present with subarachnoid hemorrhage. There is a dearth of literature on the clinical significance of intra- aneurysmal thrombus, with contradictory statements, especially with reference to the prevention of bleeding by the thrombus inside the aneurysm sac. It has been suggested by some authorities that intraluminal thrombus contributes to the strength of the aneurysmal wall by forming a latticework structure, thereby preventing hemorrhage [5,14]. While, others believe that even when a giant aneurysm has been completely replaced by a thrombus, it does not offer any protection against rupture [7,10,11]. In all of these series, there was no significant difference in the rates of subarachnoid hemorrhage between thrombosed and non-thrombosed aneurysms. The authors arguing against the protective role of thrombus suggest that the process of thrombus formation is very non-uniform due to the presence of flow pattern related factors, turbulence and the pattern of endothelial damage, which is non continous. Therefore, the fibrocalcified arears of the thrombosed aneurysm alternate with weak areas, where the rupture is most likely to happen.

The issue of distal thrombo-embolic phenomenon from thrombosed aneurysms is very uncertain, with various series reporting the incidence to be in the range of 5-59% [7,11,15-18], but the incidence is definitely more than with non-thrombosed aneurysms. Another issue in the thrombosed aneurysms is the parent artery occlusion by the thrombus, the possibility of which is extremely low, according to various series in the literature. There have been very few cases till date with total or partial parent artery occlusion in the presence of intra-aneurysmal thrombus [7,19-21].

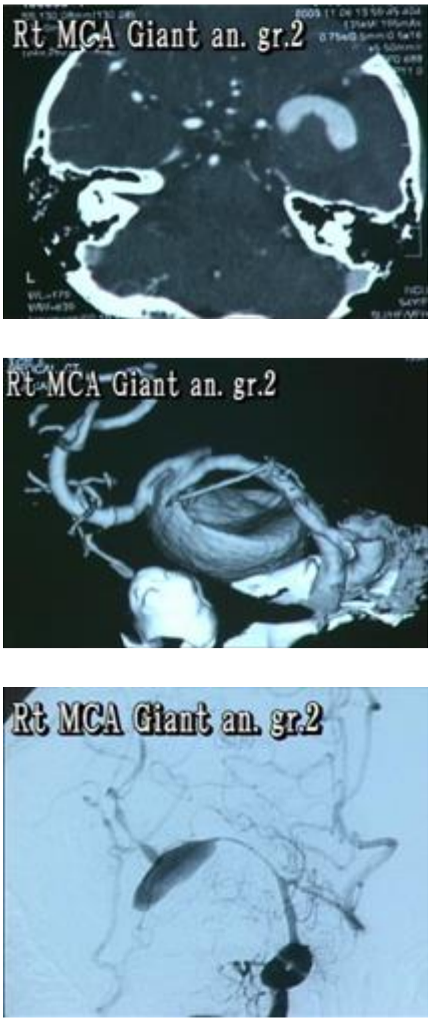
Diagnostic Imaging

Computed Tomography scan has greatly helped in the diagnosis of atheromatous aneurysms. The pathognomic features of these aneurysms have been very well documented previously in several published reports [22-24]. The feature considered to be diagnostic of these lesions is the disparity in the size on CT scan and angiography. Other features which are consistent with the diagnosis of thrombosed aneurysms are ‘Target Sign’, peripheral ring enhancement, calcification of the aneurysm wall and giant serpentine aneurysms [2,3].

The different possible differential diagnosis of these lesions includes pituitary adenoma, epidermoid, meningioma, glioma, acoustic neuroma and craniopharyngioma. Computed Tomography Angiography is especially helpful in assessing the degree of calcification involving the neck, which is very essential in the preoperative planning to estimate the difficulty encountered in the clipping of thrombotic aneurysms [Fig. 1 A,B,C]. The presence of significant calcifications in the neck will render the aneurysm unclippable and would also at the same time risk tearing of the aneurysm by the closing pressure of the blades.

Figure 1:
A. Contrast Enhanced MRI of a patient showing a giant partially thrombosed Rt sided MCA aneurysm

B. 3- dimensional Computerized tomography angiography (3-D CTA) of the same patient showing considerable disparity in the size and shape of partially thrombosed aneurysm
C. Digital Subtraction Angiography of the same patient with partially thrombosed aneurysm.



Issues in the management of thrombotic aneurysms

The thrombotic aneurysms pose a significantly different challenge to the operating neurosurgeon. They can be considered as a diverse set of complex aneurysms with a solid intraluminal mass and/ or calcified walls and neck. The aneurysmal clipping requires a pliable neck that can be closed by clip blades. This objective may not be reached successfully if the aneurysm neck is atherosclerotic, heavily calcified or is partially or totally occluded with thrombus. Henceforth, their surgical management may require methods other than conventional clipping. There are various surgical options in the management of this distinct entity: conventional clipping, trapping without bypass, bypass and aneurysm occlusion or thrombectomy and clip reconstruction [Fig. 2].

Figure 2:

A. Peroperative view of a patient with giant partially thrombosed aneurysm. The aneurysmal sac has been opened and thrombectomy is being done
B. Reconstruction of the aneurysmal neck being performed using fenestrated clips
C. Completed reconstruction of the neck by using a combination of four fenestrated clips.

Lawton et al [25] reported the anatomic characteristics and surgical experience with this distinct subset of aneurysms and devised a new classification scheme with type-specific treatment strategies. They classified thrombotic aneurysms into six subtypes on the basis of aneurysm thrombus and lumen morphology and correlated these anatomic features to the specific surgical techniques. These six subtypes were: concetric, eccentric, lobulated, complete, canalized and coiled. The aneurysm management consisted of direct clipping, thrombectomy- clip reconstruction, bypass with aneurysm occlusion, trapping without bypass and simple observation. Concentric thrombotic aneurysms were treated with thrombectomy- clip reconstruction or bypass occlusion. Direct clipping could not be achieved in the majority of these aneurysms. About one-third of the eccentric thrombotic aneurysms required thrombectomy as the thrombus prevented adequate clip closure on the aneurysmal necks. Lobulated aneurysms were treated with clipping with or without thrombectomy. The majority of canalized thrombotic aneurysms were treated with bypass occlusion, while coiled thrombotic aneurysms were clipped directly in almost half of the cases. They could achieve complete angiographic obliteration in 97% of their patients. These authors concluded that about one-third of the thrombotic aneurysms can be treated with direct clipping method and proposed that the classification of these aneurysms into six different subtypes helps in identifying those aneurysms which can be adequately clipped. They further proposed that direct clipping is associated with best surgical results and those patients with unclippable necks have more favorable results when treated with bypass and aneurysmal occlusion rather than with thrombectomy and clip reconstruction.

Hoh et al [26] in their experience with unclippable and uncoilable aneurysms also used these approaches with favorable results. They used some other strategies in rare circumstances in order to deal with these aneurysms, such as excision and anastomosis, excision and interposition graft, surgical or endovascular flow reversal/ alteration and intracranial stenting with coiling.

Several authors in the literature [25,26,27] have described various principles in the surgical management of these treacherous aneurysms. These are the use of Cavitron ultrasonic aspirator, intraoperative angiography, clipping under hypothermic circulatory arrest. Other important principles are the judicious use of temporary clips, use of tandem clips and suction decompression of the aneurysmal dome.

Sano et al in their review of 18 patients [27] concluded that partially thrombosed giant aneurysms are one of the most difficult diseases faced by the cerebrovascular surgeon. Nine aneurysms were clipped, two aneurysms were removed with anastomosis, two cases were treated interventionally, and five cases were treated conservatively because of serpentine and fusiform types of aneurysms in internal carotid artery bifurcation. These conservatively treated patients died due to infarction.

They proposed that when surgery is selected in the thrombosed giant aneurysms, approach and preoperative planning are the most important in order to successfully secure the neck. In their series, three- dimensional computed tomography angiography proved to be very useful in planning the strategy for surgery [Fig. 1B]. If the neck is big enough for placement of a clip, arterial reconstruction should be the choice of surgical treatment. The reconstruction must be done including an adequate size of the artery because of the thick wall. If the aneurysm neck is too small to reconstruct, aneurysmectomy with anastomosis is one of the choices.

Uede et al [28] reviewed 22 cases of large or giant thrombosed aneurysms treated surgically at their center. Direct clipping could be achieved in 16 patients. Out of them, 2 giant basilar aneurysms were clipped under hypothermic circulatory arrest. Simple trapping of the parent artery and trapping with bypass graft was carried out in 3 aneurysms each. 10 patients had uneventful recovery, while 11 had mild to severe disability. These authors concluded that adequate preoperative assessment and peroperative management of the associated thrombus and the atherosclerotic changes at the neck of the aneurysm are essential for satisfactory surgical results in the treatment of these lesions.

Therefore, to conclude, despite the advances in microsurgery and endovascular surgery, these subsets of aneurysm remain extremely difficult to treat and remain an operative enigma to the operating neurosurgeon. It is noteworthy that the indications for both the endovascular and surgical clipping of the aneurysms are more or less similar.

Therefore, as more and more of the simple aneurysms are coiled due to the developments in endovascular techniques, we as surgeons should expect increasingly complex aneurysms like these, to require surgical intervention. In future, complex and surgically challenging aneurysms like these would be more frequently faced by the neurosurgeons. With careful preoperative planning, experience, and innovations in managing these treacherous lesions, excellent surgical results can be achieved in these aneurysms that are not currently amenable to endovascular techniques.

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