Management of intracranial aneurysms

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Introduction
Management of intracranial aneurysms (IAs) has advanced over the past decades due to advances in imaging and endovascular techniques of unruptured and ruptured aneurysms. In this article we aim to provide an overview of intracranial aneurysms and their management with advances in endovascular techniques.

Intracranial aneurysms
IAs commonly occur at branch vessels and bifurcations, and come in different orientations, sizes and shapes. Saccular aneurysms are the commonest, however, fusiform, mycotic and dissecting aneurysms can also occur.1

The natural history of IAs is significantly different if it is ruptured or unruptured. Multiple studies have looked into the natural history, risk factors, rupture rates and optimal management techniques of ruptured and unruptured IAs.

Aneurysm rupture occurs in 6-16 patients per 100,000,2 and a systematic review of unruptured IAs estimated the prevalence of unruptured IAs between 2-3.2%.3,4

Multiple risk factors have been identified in relation to intracranial aneurysms, with smoking posing the most significant risk.1 Hypertension and raised cholesterol are other recognised risk factors. There is increased risk of rupture of coexistent aneurysms in patients with IA rupture at other sites. Patients with a family history of IAs and with autosomal dominant polycystic kidney disease are at increased risk of developing IA.5

Ruptured IAs
Ruptured IAs present with acute severe thunderclap headache, leading to reduced consciousness and reduction in the Glasgow Coma Scale. The International Subarachnoid Aneurysm Trial (ISAT), a multi-centre prospective trial looking into the efficacy and safety of endovascular treatment (EVT) against surgery in patients presenting with acute aneurysmal SAH deemed suitable for both treatments at time of presentation, demonstrated statistically significant superior outcomes (ie dependent or dead at one year) for patients treated with EVT compared to surgery.6 Methods of EVT will be discussed later.

Unruptured IAs
These present incidentally on imaging, or with signs and symptoms of third cranial nerve palsy, but the commonest presenting symptom is headache.5,7 The International Study of Unruptured Intracranial Aneurysms (ISUIA), a multi-phase pan-European North American population-based study, is the most prominent study to date looking into IAs.7,8

The risk of rupture for saccular aneurysms correlates with its size and location. ISUIA concluded that aneurysms less than 7mm in diameter are the least likely to rupture over a cumulative five-year period (<0.01%). The risk of IA rupture increases with size. The risk of rupture is greater for posterior circulation aneurysms in comparison to aneurysms of the anterior cerebral circulation.9

Patients with unruptured intracranial aneurysms are invited to neurovascular clinics to assess the lifetime risk of rupture against the risks posed with treatment. Aneurysm location, size, symptomology, family history, patient age and comorbidities play a major role in deciding the optimal treatment pathway.

Imaging of intracranial aneurysms
IAs are imaged using several modalities that include computed tomography (CT), CT angiography (CTA), magnetic resonance imaging (MR), MR angiography (MRA), and digital subtraction angiography with 3D acquisitions. Each modality supplements the other in acute and elective management IAs.

Follow-up or screening of IAs is performed with MR and MRA, eliminating radiation exposure. Time-of-flight MRA is the accepted technique for interval screening and follow-up of treated aneurysms. At best, spatial resolution of MRA with a 1.5T magnet is 1mm³ and 0.6mm when acquired with a 3.0T MR.9,10 MRA is sensitive to motion and therefore patients are required to remain static as sequences are acquired.

CT and CTA are employed in patients with suspected acute subarachnoid haemorrhage. CTA has a spatial resolution between 0.4-0.7mm on a 64 multidetector CT11 and has a high diagnostic yield between 96-98% for aneurysms larger than 3mm.12 Images can be obtained within a fraction of time it takes to acquire an MR/MRA. It also has the advantage of detecting calcification and depicting relevant bony details for surgical planning.

Digital subtraction angiography (DSA) is performed as: 1) a screening tool to identify aneurysms not identified on CTA; 2) to plan and proceed with treatment if deemed appropriate. Advances in flat panel technology and 3D imaging software have revolutionised the role of DSA. DSA and 3D DSA have a spatial resolution of 0.2mm and 0.15mm respectively, allowing for increased detection of aneurysms smaller than 3mm.13 DSA is a minimally invasive technique, requiring the use of catheters and guiding wires to obtain angiographic images of the cerebral circulation. It is therefore associated with risks including stroke. The risk is around 0.3% with experienced neuroradiologists.14

Endovascular treatment of IAs
The advent of platinum coils with a controlled detachable system and safe deployment was the first important step in EVT of intracranial aneurysms.15,16 It is performed under a general anaesthetic with placement of coils via a microcatheter introduced through larger guide catheters from the femoral route.

Many series looking into procedural morbidity and mortality demonstrated acceptable rates of complications, with rates of complications slightly higher in the treatment of acutely ruptured IAs compared with elective coil embolisation of the unruptured group (13.3% and 3.7% vs 7.3% and 2.0%),17,18
The risk of thromboembolic event has led to the intraoperative use of heparin and antiplatelet agents. The most frequent complications associated with coating are stroke, and intra-procedural aneurysm rupture and death.\(^{12,20}\)

Complex large and giant aneurysms, wide necked aneurysms and aneurysms with an unfavourable size relationship between dome, neck and parent vessel, are challenging to treat with coils alone, with recanalisation rates of up to 20.8%\(^{12,22}\) and retreatment required in 10.3% of cases.\(^{22}\)

The Cerebral Aneurysms Rerupture after Treatment (CARAT) study identified the degree of aneurysm occlusion as a strong predictor for aneurysm rupture and re-presentation with acute subarachnoid haemorrhage.\(^{24}\) Given the risk of recanalisation and rupture of these aneurysms, follow-up with MRA or DSA is advocated at appropriate intervals.\(^{24-27}\)

Given the difficulties in complex aneurysms, new technologies and mechanisms emerged for their treatment. These techniques include balloon-assisted coiling (BAC), stent assisted coiling (SAC), flow diversion (FD) and endosaccular devices (WEB). Moret al et first described BAC in 1997.\(^{20}\) A non-detachable expandable balloon is guided into the parent vessel at the level of the aneurysmal neck. Prior to deployment of the coil, the balloon will be inflated using diluted contrast, keeping coils away from the parent and branch vessels. The technique is used in ruptured and unruptured aneurysms. SAC overcomes the problems of wide neck aneurysms, similar to the BAC technique.\(^{20-22}\) The stent is placed into the parent vessel across the neck of the aneurysm (figure 2).

With SAC, the risk of clot formation is higher than coiling alone and hence pre and post treatment antiplatelet therapy is mandatory. The SAC technique is mainly used in the non-ruptured elective setting, as patients have to be medicated with antiplatelet agents.

Flow diverters (FD) (pipeline embolisation device (PED) being the most commonly used device) is a relatively new method of endovascular treatment.\(^{12}\) A low porous stent implant is placed in the parent vessel bridging the neck of aneurysm. The structure of the stent enables redirection of blood flow away from the aneurysm, promoting the formation of stable intra-aneurysmal thrombus (figure 3). Preliminary data presented by the investigators from the Pipeline for Uncollapsible or Failed Aneurysms (PUFS) trial demonstrated positive long-term outcomes, with a 95% aneurysm occlusion rate reported at five years.\(^{23}\)

A recent, innovative intrasaccular treatment for IAs was introduced in 2010. The Woven Endobridge (WEB) aneurysm embolisation system was developed specifically for the treatment of wide necked bifurcation aneurysms (figure 4).

The results of two early prospective multicentre European studies (WEBCAST and French Observatory), recruiting 113 patients, demonstrated safe and feasible deployment of the WEB device in 95.6% of patients with high occlusion rate (82%) and low rate of neck remnant (26%) on follow-up anatomic evaluation,\(^{14}\) which is low comparable to coiling alone as reported in the CLARITY study (46-49%).\(^{14}\)

Thromboembolic events and rupture rates were 15% and 0.5% respectively, but none were associated with permanent clinical worsening.\(^{14}\) The results are promising and further data is required on the long-term stability of this technique and patient outcomes.

Parent vessel occlusion is a technique employed in disecting ruptured aneurysms or a giant aneurysm causing mass effect if there are no other treatment alternatives. It is usually performed with coils once the blood supply of the targeted vessel is confirmed from collateral circulation.

Conclusion

IAs are a common cause of anxiety, morbidity and mortality. Advances in imaging technology with clinically proven existing and emerging EVT, along with optimal peri and post operative care in a dedicated neuroscience set-up, has gradually and significantly improved patient clinical outcomes.

References

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Figure 1
Angiogram (A) demonstrates a terminal internal carotid aneurysm (ICA). (B) shows the coiling technique of the terminal ICA aneurysm. (C) demonstrates inflation of the balloon at the level of the aneurysm neck. (D) demonstrates a successful balloon-assisted coil embolisation excluding the terminal ICA aneurysm from the circulation.

Figure 2
Angiogram (A) demonstrates a coiled basilar tip aneurysm recurrence. (B) shows the struts of the deployed stent, yellow arrow – distal landing strut, red arrow – proximal landing strut. Additional coils have been deployed into the recurrence. (C) demonstrates complete occlusion of the basilar tip aneurysm following successful stent assisted coiling.
Figure 3
Angiogram (A) and (B) demonstrate a cavernous/ supraclinoid ICA aneurysm prior to PED treatment. (C) demonstrates successful exclusion of the aneurysm from the circulation.

Figure 4
WEB device deployed into the sac of a wide necked middle cerebral artery bifurcation aneurysm.