NEURYSMS arising from perforating arteries are uncommon, and have been reported in anterior circulation locations like the lenticulostriate arteries and the perforating vessels along the A1 segment of the anterior cerebral artery (also known as basal perforating vessels).9 Aneurysms arising from perforating arteries have also been reported in the posterior circulation, particularly associated with thalamoperforating arteries at the basilar apex and the P1 segment of the PCA.2–4 Perforating artery aneurysms were categorized into two types by Maeda et al.,3 with one type located at the origin of the perforating vessel in the subarachnoid cisterns, and the other type located distally on the perforating artery. This type of distal perforating artery aneurysm is especially rare, with few reports in the literature. Distal aneurysms arising from the circumferential branches of the BA are also exceedingly rare, with no previous reports to our knowledge. We treated one patient with a basilar perforating artery aneurysm originating distally along the parent artery and two patients with distal aneurysms of basilar trunk circumferential arteries. We report the diagnostic features of these exceptionally rare aneurysms, their microsurgical management, and treatment results.

Case Reports

Case 1

History and Examination. This 27-year-old man presented with sudden, severe headache that occurred while he was lifting weights. His medical history was noncontributory and results of his neurological examination were normal. A head CT scan revealed SAH in the prepontine and interpeduncular cisterns, and the CT angiogram did not reveal any aneurysmal source of bleeding. A catheter angiogram also demonstrated normal findings, without aneurysm, arteriovenous malformation, or dissection. The patient did not suffer vasospasm and was discharged.
Distal aneurysms of basilar arteries

home with improving headaches. He returned to the hospital 2 months later with another severe headache. A repeated head CT scan demonstrated acute bleeding in the same location as the first hemorrhage, but in a circumscribed distribution rather than diffuse SAH (Fig. 1). Results of a CT angiogram suggested a 6-mm-diameter aneurysm originating from the posterior wall of the BA bifurcation, slightly eccentric to the right side. A catheter angiogram was initially interpreted as negative for aneurysm by the attending neuroradiologist, but further review of anteroposterior views revealed a faint, circular blush behind the BA bifurcation that was best visualized in the capillary and venous phases of the angiogram. The lateral view showed the same slow-filling aneurysm, with a central void of contrast agent suggesting only peripheral filling of the lumen. These findings were interpreted as a centrally thrombosed aneurysm, and the patient was taken to the operating room for exploration of the lesion.

Operation. The patient underwent a right orbitozygomatic–pterional craniotomy and the aneurysm was exposed via a transsylvian approach. A small perforating artery was seen originating from the dorsal aspect of the BA bifurcation and coursed 4 to 5 mm through the interpeduncular cistern, where it fed the aneurysm (Fig. 2). On gross inspection, the aneurysm was dolichoectatic and almost completely thrombosed, but with each heartbeat, arterial blood could be seen to enter the luminal space between central thrombus and the aneurysm wall. The feeding perforating artery was coagulated and divided, and the aneurysm was opened to remove the thrombus (Fig. 2D).

Postoperative Course. A postoperative angiogram demonstrated complete obliteration of the aneurysm. The patient remained neurologically intact and was discharged home.

Case 2

History and Examination. While visiting relatives in China, this 68-year-old man experienced a sudden, severe headache with associated dizziness, double vision, and left hemiparesis. Admission CT scans demonstrated diffuse SAH and a right parietal intraparenchymal hemorrhage. Catheter angiography was reportedly negative for aneurysm, arteriovenous malformation, or other vascular abnormalities. He returned home 2 months later and presented to our institution for further evaluation.

A CT angiogram revealed a 5-mm aneurysm located in the right CPA (Fig. 3). Subsequent catheter angiography revealed an aneurysm originating from a circumferential branch of the BA, just proximal to the origin of the AICA. Oblique angiographic views demonstrated no connection to the AICA. Considering the appearance of this previously undetected aneurysm and the patient’s SAH, it was decided to treat this aneurysm microsurgically.

Operation. The aneurysm was exposed through a right extended retrosigmoid craniotomy. The lesion was adherent to the pons, flocculus, and choroid plexus in the foramen of...
Luschka. It had separate inflow and outflow arteries on opposite sides, which were both occluded to trap the aneurysm. It was resected for pathological analysis, which revealed a characteristic aneurysm wall without evidence of inflammation or infection. There was some organized intraluminal thrombus, suggesting that the aneurysm was angiographically occult initially due to thrombosis.

**Postoperative Course.** The patient tolerated his surgical procedure without neurological sequelae. The postoperative angiogram demonstrated complete elimination of the aneurysm.

**Case 3**

**History and Examination.** This 2-year-old boy presented to the emergency room after sustaining blunt head trauma. He was being carried in his mother’s arms when she stumbled and fell to the floor. The boy’s occiput struck the floor, and bore some of the mother’s weight at impact. His medical history was noncontributory. Results of the boy’s neurological examination were completely normal.

A CT scan revealed subarachnoid blood in the left CPA, with a left posterior temporal skull fracture. A repeated head CT scan obtained 5 days later demonstrated enlargement of the subarachnoid clot, without new hemorrhage. Subsequent MR imaging demonstrated a rounded signal flow void within the center of the subarachnoid clot with Gd enhancement, which was suggestive of a traumatic pseudoaneurysm (Fig. 4). Catheter angiography confirmed an aneurysm that arose from a basilar circumferential artery just distal to the origin of the AICA. In addition, the BA was irregularly narrowed in a pattern consistent with mild vasospasm. This vasospasm remained clinically asymptomatic, and another angiogram obtained 2 weeks after the trauma showed persistence of the pseudoaneurysm. It was decided to treat the aneurysm microsurgically because the small caliber of the parent artery precluded an endovascular treatment.

**Operation.** The patient underwent an extended retrosigmoid craniotomy to access the CPA and expose the aneurysm. The AICA was identified distally and dissected medially to the basilar trunk. The aneurysm was covered in thrombus and adherent to the pons. There were no connections from the AICA to the aneurysm, and control of the BA proximal and distal to the aneurysm was gained. The aneurysm was then rolled away from the pons to identify the afferent artery and abducent nerve along the lesion’s medial border. The afferent artery was occluded with an aneurysm clip and the efferent artery was cauterized, thereby trapping the lesion. The aneurysm lumen was filled with thrombus but had an organized component that matched the angiographic findings. There were no changes in the neurophysiological monitoring throughout the case (somatosensory and motor evoked potentials).

**Postoperative Course.** Postoperatively, the patient remained neurologically intact. A postoperative angiogram revealed complete elimination of the aneurysm (Fig. 4F). The patient made an excellent recovery.
Discussion

Perforating and Circumferential Artery Aneurysms

Perforating artery aneurysms in the posterior circulation are rare, with only two others reported in the literature in addition to our cases.\(^3\,^4\) Circumferential artery aneurysms are even more rare, and we could not find any other report in the literature. Aneurysms arising proximally from perforating and circumferential arteries along the BA or the P\(_1\) segment of the PCA are probably underreported because their features are similar to small aneurysms elsewhere and their treatment is straightforward. For example, in the senior author’s (M.T.L.) experience in the course of 8.5 years with 1434 aneurysms in 1144 patients, only 11 patients had small aneurysms on the P\(_1\) segment of the PCA that were treated with microsurgical clip occlusion. Four of these lesions were unruptured and were clipped during craniotomy for multiple unruptured aneurysms; three of the 11 were unruptured and were clipped during craniotomy for another ruptured aneurysm; and the other four were solitary aneurysms, two of them unruptured and two of them ruptured.

In contrast to proximal perforating artery aneurysms, distal perforating and circumferential artery aneurysms are exceptionally rare. Our three examples of these types of aneurysms demonstrate that location can vary to involve any perforating or circumferential artery in the posterior circulation. The etiology is also variable; two of our patients had standard aneurysms and clinical presentations with SAH, whereas one had a traumatic presentation and a pseudoaneurysm. Features common to all three distal perforating and circumferential artery aneurysms were dolichoectatic morphology and intraluminal thrombus. Distal location and dolichoectatic morphological features suggest a pathogenesis different from saccular aneurysms that form at bifurcations exposed to high blood flow and shear stress. Perforating and circumferential parent arteries have low blood flow, low hemodynamic stress, and few branches. The presence of intraluminal thrombosis in these aneurysms may be involved somehow in their formation, or it may be a response to rupture, but this limited clinical series does not answer the question of pathogenesis for nontraumatic aneurysms.

Challenges in Diagnosis

This clinical experience demonstrates how challenging these aneurysms can be to diagnose. In two of the three patients, the angiograms were initially read as negative for aneurysms, due to intraluminal thrombus after rupture. The third patient’s angiogram was positive initially, but was performed 1 week after the traumatic event and might not have been positive if it had been performed earlier. Negative angiograms in these patients could have led to the misdiagnosis of nonaneurysmal perimesencephalic venous hemorrhage,\(^8\) which might have precluded follow-up angiography. Perforating and circumferential artery aneurysms should be remembered when evaluating patients with angiogram-negative SAH. We recommend repeat angiographic studies 3 to 6 months after negative findings on angiography performed during the initial hospitalization.
Even with the appropriate follow-up angiography, these distal perforating and circumferential artery aneurysms are difficult to visualize because they are slow to fill, do not opacify in the arterial phases like other aneurysms, and are best seen by scrolling through images on a computer monitor. A high index of suspicion for aneurysm and the integration of other imaging modalities into the analysis are required to spot these sometimes subtle lesions, as in our patient with the basilar apex aneurysm. In that case, the three-dimensional CT angiography was particularly helpful, but only after the patient was readmitted later, after there was some reabsorption of luminal thrombus.

The anatomy of these aneurysms is often difficult to decipher from the diagnostic imaging. The afferent and efferent arteries are so small in caliber that the anatomy is obscured. Intraluminal thrombus is dynamic, so the luminal blood flow changes over time, as does the aneurysm itself, particularly with pseudoaneurysms.

**Microsurgical Management**

None of the perforating or circumferential artery aneurysms in this series were amenable to endovascular therapy. In general, coil occlusion is preferred for aneurysms below the basilar apex and above the posterior inferior cerebellar artery because of the favorable results with coil placement and the difficulties in exposing these lesions surgically. However, the parent artery for perforating and circumferential artery aneurysms is difficult to visualize and even more difficult to catheterize. The distal location of these lesions further complicates endovascular therapy. Therefore, microsurgical management is the only treatment option for these aneurysms.

These types of aneurysms are not amenable to conventional clip occlusion because they have no necks. In our case series, all three aneurysms were trapped. The parent arteries in all cases were diminutive, and would not lend themselves to revascularization techniques such as reanastomosis of the parent artery or an extracranial–intracranial bypass. Furthermore, such techniques are not necessary. Natural anastomoses exist between adjacent perforating arteries along the basilar trunk, providing collateral blood flow if one branch is occluded. These collateral vessels do not exist at the basilar apex, but in our one case of a lesion in that location, the efferent artery was already occluded and our intervention caused no neurological sequelae. Therefore, aneurysm trapping for distally located perforating and circumferential artery aneurysms seems to be tolerated, and the good results in our three patients support this treatment technique.

The extended retrosigmoid approach provided adequate exposure for the aneurysms off the basilar trunk, and a more extensive skull base approach was not necessary. During aneurysm dissection, it is important to control the BA proximally and distally to the parent artery, and to dissect uninvolved branches like the AICA or PCA away from the aneurysm to protect them. Miniclips were used to occlude...
Distal aneurysms of basilar arteries

the parent arteries whenever there were adjacent cranial nerves. For example, the abducent nerve was intimately related to the traumatic pseudoaneurysm, and coagulation of the afferent artery might have caused thermal injury to this delicate nerve. Aneurysm excision is not necessary, but internal thrombectomy might be considered to debulk the aneurysm sac and decompress adjacent cranial nerves.

Conclusions

Distal perforating and circumferential artery aneurysms can arise from the BA and cause SAH. These aneurysms may be difficult to diagnose given their small size and delayed filling on angiographic studies. Consequently, their involvement in cases of angiogram-negative SAH may be underestimated. These aneurysms are not amenable to endovascular treatment, but excellent results can be obtained with microsurgical exposure and trapping.

References


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