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Neurosurgical management of posterior communicating artery aneurysmal perforators. Technical note through two case examples

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Abstract

Background: Posterior communicating artery (PCom) aneurysms are prevalent intracranial aneurysms, frequently leading to subarachnoid haemorrhage and third nerve palsy. "True" perforators originating directly from the PCom aneurysmal sac are rare and pose unique surgical challenges. We present two illustrative cases where "true" PCom perforators were identified during surgery, necessitating tailored microsurgical approaches.

Case Reports: In case one, a 35-year-old female presented with a large PCom aneurysm. During surgery, a modified clipping technique successfully preserved a perforator originating from the aneurysmal sac. In case two, a 36-year-old male with a PCom aneurysm was found to have a perforator supplying the mesial temporal cortex. Sacrificing this perforator was necessary for aneurysm clipping.

Conclusion: This paper underscores the rarity of "true" PCom perforators and their impact on microsurgical approaches. Preoperative imaging techniques often fail to detect these small-calibre vessels, highlighting the importance of intraoperative identification. Tailored approaches based on individual anatomy and clinical context are essential. While endovascular procedures provide alternatives, adaptability in microsurgical techniques remains crucial for cases requiring intraoperative perforator management. Overall, understanding the complex vascular intricacies of PCom aneurysms, including "true" perforators, is vital for neurosurgeons. The delicate balance between preservation and necessity, along with ongoing research for improved preoperative identification, stands as the cornerstone for enhancing surgical outcomes in these complex cases.

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Introduction

Posterior communicating artery (PCom) aneurysms are common, accounting for 25% of all intracranial aneurysms with a 48% rupture rate (1,2,12). Ruptured Pcom aneurysms have several variable symptoms. Typically, PCom presents with subarachnoid hemorrhage (SAH) and 3rd nerve palsy (1,6). Peri-aneurysmal perforating arteries (perforators) are small millimetre or submillimetre calibre vessels arising from the parent vessel in the vicinity of intracranial aneurysms. Peri-aneurysmal perforators have a variable incidence depending on the aneurysm site (7). Perforators are typically identified intraoperatively; only a small subset is visible in digital subtraction angiography (DSA) or computerized tomographic angiography (CTA) (3,7,9).

Perforating branches derived directly from parts of the aneurysm may be described as "true" perforators, as opposed to "peri-aneurysmal" perforators emerging from the parent vessel (Figure 1: A, B). Reports on “true” perforators are available on the basilar tip, internal carotid artery bifurcation, and anterior communicating artery aneurysms (7). Two cases of ruptured Pcom aneurysms characterized by intraoperatively-identified "true" perforators are reported in this paper, to document this rare finding and highlight its potential intraoperative implications.

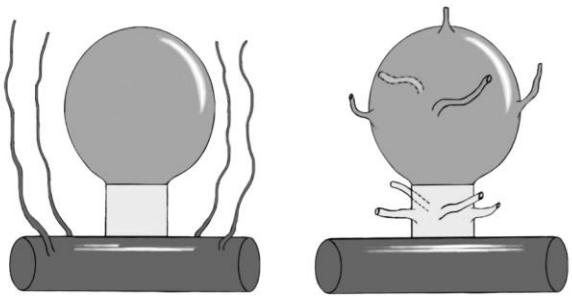

Figure 1. A: Peri-aneurysmal perforators arising from the parent vessel segments near the aneurysm. **B:** Potential locations for “True” Pcom perforators branching directly from the dome or neck of the aneurysm.

Illustrative cases

Case one

An otherwise healthy, 35-year-old female had a sudden-onset, severe headache associated with meningismus. The patient was awake, alert, and oriented to person, time, and place. Neurological examination revealed a left-sided third nerve palsy. A brain computed tomography (CT) scan showed SAH in the basal cisterns. The CTA showed a large (14mm) Pcom aneurysm (Figure 2A).

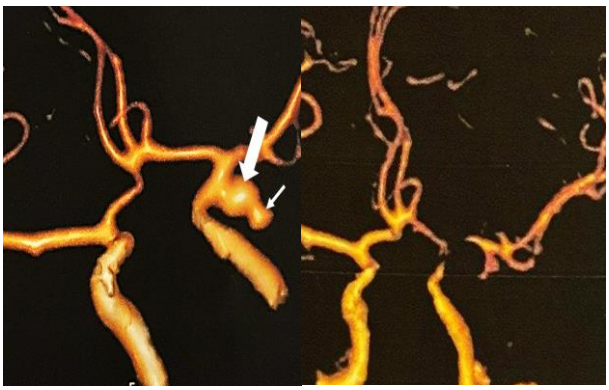

Figure 2. Cerebral CT angiography (3D reconstruction). **A**: Preoperative image showing a large left posterior communicating artery aneurysm (thick arrow) directed postero-laterally. A daughter cyst (thin arrow) is also seen. **B**: Postoperative image showing complete clipping of the aneurysm with no residual neck.

No endovascular facility was available in our country, leaving microsurgical clipping as the only possible mode of intervention. Microsurgical clipping of the aneurysm, through a standard, left-sided pterional, trans-Sylvian approach was planned. The patient was positioned supine with the head tilted 30 degrees to the right side. After the removal of the lateral part of the sphenoid ridge, the carotid cistern and the proximal part of the Sylvian fissure were opened. Dissection of the internal carotid artery was then carried out until the aneurysm dome and neck became visible. Next, the aneurysm neck was dissected. A relatively large perforating artery was found originating from the posterior part of the aneurysmal dome, a few millimetres from the aneurysm neck, (Figure 3A-B). The distal course of the perforator could not be confirmed. Thus, a decision was made to preserve the perforator by reconstructing the aneurysm neck with a modified clipping technique, using two tandem clips to exclude the aneurysm from circulation. The distal clip closed the major part of the aneurysm sac while the proximal one left a small residual neck posteriorly to maintain blood flow to the perforator, (Figure 3C-F). The patency of the perforator was confirmed by intraoperative Doppler ultrasonography.

The postoperative course was uneventful, and the patient's preoperative 3rd nerve palsy recovered completely. The post-operative CTA confirmed that the aneurysm was now clip-secured (Figure 2B). The patient was discharged home seven days post-operatively. At her six-month follow-up, the patient was well and both the CT and CTA studies showed no new significant findings.

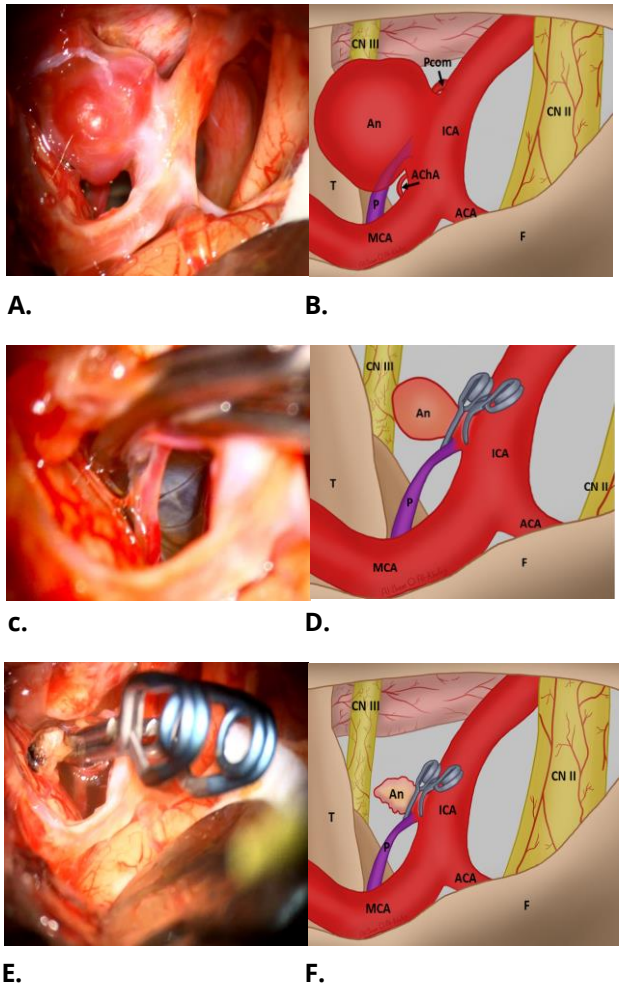

Figure 3. Intraoperative images of microsurgical clipping of posterior communicating artery aneurysm with illustrations. **A-B**: Pre-clipping image showing the perforator (P) arising from the posterior dome of the aneurysm (An), a few millimeters from its neck. The posterior communicating (Pcom) and anterior choroidal (AChA) arteries are seen arising from the proximal and distal neck of the aneurysm, respectively. **C-D**: Zoomed in view showing the application of a clip distal to the origin of the perforating branch, fully occluding the aneurysmal sac distal to it. A second clip is applied at the level of origin of the perforating branch, occluding most of the aneurysmal neck apart from its posterior part, maintaining flow to the perforating artery. **E-F**: Zoomed out view showing dissection and cauterization of the aneurysmal dome from the oculomotor nerve (CN III). ACA: anterior cerebral artery, AChA: anterior choroidal artery, An: aneurysm, CN II: optic nerve, CN III: oculomotor nerve, F: frontal lobe, ICA: internal carotid artery, MCA: middle cerebral artery, P: perforator, T: temporal lobe.

Case two

A previously healthy, 36-year-old male was admitted with the complaint of an acute, severe headache of three-day duration, along with one seizure episode. The patient was awake, alert, and oriented to person, time, and place. Neurological examination was within normal limits. Admission brain CT scan showed SAH in the basal cisterns, particularly in the suprasellar cistern, extending to the left Sylvian fissure. Cerebral CTA revealed a large (10mm) elongated left-sided Pcom aneurysm, with a marked narrowing of the supraclinoid segment of the internal carotid artery (ICA) on the left side, suggesting arterial vasospasm (Figure 4).

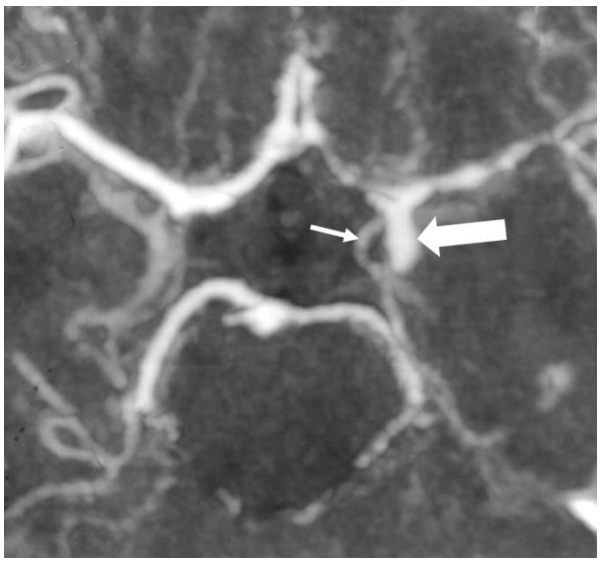

Figure 4. Pre-operative CTA showing a posteriorly projecting saccular aneurysm (thick arrow) originating from the communicating segment of the left ICA. The Pcom artery (think arrow) can be seen originating from the neck of the aneurysm. Marked vasospasm of the left supraclinoid ICA as well as the ACA and MCA can be seen.

Microscopic aneurysm clipping was planned using the left pterional trans-Sylvian approach. Following the dissection of the Sylvian fissure, the ICA and the aneurysmal neck were dissected. A relatively large perforating artery arising from the mid-part of the anterior surface of the aneurysm dome was discovered (Figure 5A-B). Following the course of this perforator showed that it supplied the mesial temporal cortex. Because of this perforator's source

site, we were forced to sacrifice it so that the aneurysm could be clipped while holding the Pcom patent (Figure 5C-F).

There were no surgical complications and the postoperative recovery was uneventful. The post-operative CTA showed occlusion of the aneurysm with the resolution of the vasospasm (Figure 6). The patient was discharged on day eight post-operatively. At his nine-month follow-up, the patient was well with no neurological deficits and both the CT and CTA studies showed no new significant findings.

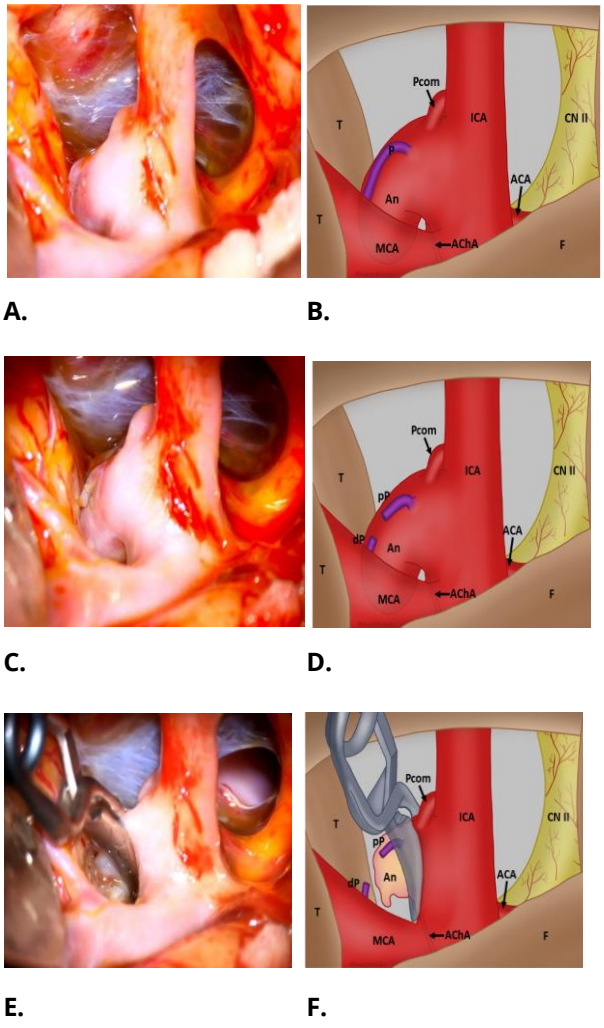

Figure 5. Intraoperative images of microsurgical clipping of posterior communicating artery aneurysm with illustrations. **A-B**: Pre-clipping image showing the perforator (P) arising from the anterior mid-sack of the aneurysm (An). The posterior communicating artery (Pcom) is seen arising from the proximal neck of the aneurysm. The anterior choroidal artery (AChA) is coursing behind the internal carotid artery (ICA) with its origin from the distal neck of the aneurysm. **C-D**: The proximal (pP) and distal (dP) ends of the perforator were cauterized and the segment between them cut off. **E-F**: Post-clipping image. The aneurysm was clipped using a curved clip, sparing the origins of both posterior communicating and anterior choroidal arteries. ACA: anterior cerebral artery, AChA: anterior choroidal artery, An: aneurysm, CN II: optic nerve, F: frontal lobe, ICA: internal carotid artery, MCA: middle cerebral artery, P: perforator, pP & dP: proximal & distal segments of the perforator, T: temporal lobe.

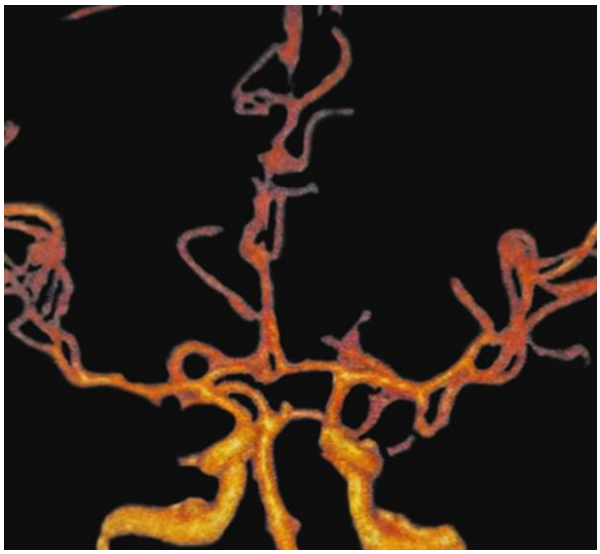

Figure 6. 8-day follow-up 3D-reconstructed CTA showing complete clipping of the aneurysm with no residual neck and resolution of the vasospasm.

Discussion

The current paper presents two case studies of “true” perforators originating from PCom aneurysms, a rarely documented phenomenon in the literature. These "true" perforators, which arise directly from the aneurysmal sac, are distinguishable from the more frequently studied peri-aneurysmal perforators (7). Our study underlines the clinical implications of such anatomic variants and points towards the need for an adapted surgical approach to manage them. Surgically, “true” PCom aneurysm perforators have only been mentioned once in the literature by Reynolds et al, who identified a small perforator originating directly from the fundus of a PCom aneurysm. Dissection of that perforator suggested that it supplied the internal capsule. The aneurysm was deemed unclippable and the perforator was maintained (8).

Aneurysms involving the PCom artery are not uncommon, they stand as one of the most frequent aneurysms encountered by neurosurgeons, ranking second in the overall prevalence of aneurysms,

accounting for a quarter (25%) of all aneurysmal cases, and a half (50%) of all internal carotid artery aneurysms (2,12). They not only present with the conventional SAH but also they can manifest as isolated oculomotor nerve palsy or non-traumatic subdural hematoma (6). In terms of surgical treatment, PCom aneurysms can be one of the most straightforward or one of the most difficult aneurysms to treat surgically. This depends on the considerable variations in the anatomy of the PCom complex, which carry substantial surgical implications (1).

Despite the known variability of PCom aneurysms and their associated vascular anatomy, there is a paucity of information about "true" PCom perforators. On average, seven perforating arteries originate from the PCom, with surgical clipping, occlusion of these peri-aneurysmal perforators is considered to cause hemiparesis and prolonged disturbance of consciousness. This presents a heightened challenge in achieving a pure separation of the aneurysm from the surrounding circulation (3,9). In addition, the presence of "true" perforators further complicates these surgical challenges and may potentially impact the choice of surgical approach and technique. In our cases, the identification of these "true" perforators dictated alterations in the conventional clipping process, thus underscoring their clinical significance.

Current imaging modalities like DSA or CTA often fall short in the preoperative identification of these small-caliber vessels. This limitation arises due to the inherently limited resolution of these imaging techniques in visualizing intricate anatomical details at a microscopic level, as the diameter of the perforators within the PCom complex spans from 0.1 to 1 millimeter (4,7,11). Therefore, this makes intraoperative identification crucial in the majority of cases. While the first case in our study emphasizes the need for careful intraoperative investigation, highlighting the pivotal role of surgical expertise, the second patient's case underlines the necessity of making complex decisions in real-time when such perforators cannot be preserved.

In non-complicated cases, most PCom aneurysms are treated with straight or curved clips. A fenestrated clip over the internal carotid artery may be required in a small number of PCom aneurysms that are large or with specific dome projections. The clip is directly positioned around the origin of the aneurysm neck while sparing vital neighboring blood vessels and perforating branches. The primary objective of the technique is to prevent blood flow into the aneurysm sac, thereby reducing the risk of rupture (9). However, our modified clipping technique for PCom aneurysms demonstrates its effectiveness through its application in our complicated cases with “true” perforators. In the first case, a straight clip was positioned distally to the origin of the perforating branch, ensuring complete occlusion of the aneurysmal sac. Subsequently, a second curved clip was positioned at the origin of the perforating branch, partially occluding the aneurysm's neck while maintaining perfusion to the perforating artery (Figure 3). Turning to the second case, prior to clipping, microscopic images revealed the perforator's precise origin from the aneurysm's anterior mid-sac, supplying the mesial temporal cortex. To enable aneurysm clipping while preserving PCom patency, we sacrificed this source. A curved clip was adroitly utilized to manage the aneurysm, without compromising the origins of the PCom and anterior choroidal arteries (Figure 5). These customized approaches were essential to preserving vital blood vessels while achieving the primary objective of optimal aneurysm closure.

The intraoperative implications of "true" PCom perforators, as demonstrated in our case studies, could be profound. They can guide decision-making regarding the preservation or sacrifice of these vessels during surgery. This choice directly relates to the risk of ischemic complications or intra-operative hemorrhage if these vessels are inadvertently injured (3). These decisions become more nuanced when the distal course of these perforators cannot be definitively determined, as seen in the first case. The use of a modified clipping technique to preserve the identified perforator helped avoid potential ischemic consequences, underlining the need for adaptability in neurosurgical interventions.

It is noteworthy that the most recent endovascular procedures are recognized as an effective approach for managing complex PCom variants. A study conducted by Kwon et al. reported a case of a giant PCom aneurysm that was treated with trapping and thrombectomy. The aneurysm had perforator arteries originating from the dome, but these arteries were successfully preserved (5). Another study by Wang et al. introduced a novel

endovascular technique called λ stenting for the treatment of PCom aneurysms with fetal-type PCom originating from the aneurysm dome. The technique was found to be safe and effective in preserving the PCom and preventing ischemic complications (10). However, in cases of intraoperative identification, as seen in our study, the versatility and adaptability of the clipping technique, emerge as the method of treatment of such variants, even when faced with unforeseen challenges in a surgical setting.

Conclusion

Our findings underline the importance of having a comprehensive understanding of the complex vasculature associated with PCom aneurysms and the potential presence of "true" perforators. While preservation should be the aim where possible, sacrifice may sometimes be unavoidable. Therefore, a tailored approach is crucial based on the individual patient's anatomy and clinical context. It is evident that further reporting and analysis are necessary to fully understand the implications of "true" PCom perforators in the intraoperative management of PCom aneurysms. The development of new imaging modalities that allow for the accurate preoperative identification of these perforators could significantly improve surgical outcomes in the future.

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