Relevance of Occlusion Test in Endovascular Coiling of Posterior Cerebral Artery (P2 Segment) Aneurysms

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Summary

P2 segment aneurysms are located on the posterior cerebral artery (PCA) between the junction of the posterior communicating artery with the PCA and the quadrigeminal cisternal part of the PCA. We reviewed our experience with endovascular coiling in such aneurysms. Clinical and pre-procedural data from four patients, referred for endovascular treatment of P2 segment aneurysms, were retrospectively studied for factors influencing post-interventional neurological deficits caused by ischemia of the PCA distal territory. Balloon occlusion was done in three patients and patient tolerance was assessed using clinical and anatomic criteria. Embryologic and anatomic features of the PCA were reviewed. Balloon occlusion test and endovascular coiling of aneurysms was possible in three patients. Control angiogram after embolization showed elimination of aneurysms from the circulation and the distal PCA filled through leptomeningeal anastomoses. One patient deteriorated due to aneurysmal rupture soon after the balloon occlusion test and coiling could not be done.

In the other three patients post-intervention CT and MRI images showed PCA territory infarcts in spite of demonstration of good collateral circulation distal to the occluded PCA. In conclusion, P2 aneurysms can be effectively treated by endovascular coiling without a balloon

occlusion test. While the balloon occlusion test does not contribute to clinical decision-making it may be associated with potential morbidity and mortality.

Introduction

Aneurysms of the posterior cerebral artery (PCA) are rare, and account for about 0.7-2.3% of all symptomatic intracranial aneurysms^{1,2} and 5-10% in autopsy series of posterior circulation in adults³. While some surgical reports discuss PCA aneurysms as a distinct subgroup^{4,5,6}, reports on endovascular treatment are few^{1-7,8}. Among PCA aneurysms, P2 segment aneurysms arise between the junction of the posterior communicating artery (PCoA) with the PCA and the quadrigeminal cisternal part of the PCA. PCA aneurysms differ from those in other sites with regard to their clinical presentation, aspects of surgical technique and prognosis^{1,5}. Our purpose was to evaluate P2 segment aneurysms as a specific entity in terms of their clinical presentation, embryologic and anatomic considerations, and endovascular treatment. We retrospectively reviewed our experience in the endovascular treatment of a series of four P2 segment aneurysms.

We studied their clinical presentation, imaging studies, endovascular management and outcomes.

Methods

Patients

Between 2000 and 2003, a total of 52 patients with posterior circulation aneurysms presented to the hospital with SAH. Four of the 52 patients had P2 aneurysms which were treated endovascularly. Three patients were male and one female, with an age range of 38-50 years (mean: 44 years).

Clinical manifestations included SAH in all cases, and SAH with intracerebral hematoma in two and contralateral motor weakness in two. Two patients were in grade II and two in grade III (Hunt and Hess). All aneurysms were partially thrombosed on imaging (figures 1-4). The diagnosis was confirmed by conventional angiography in all cases. The aneurysms were located on the left PCA in three cases (figure 1-3) and on the right PCA in one (figure 4).

Endovascular Procedure

Bilateral femoral access was obtained and balloon test occlusion was performed in three cases in the awake state. The procedures were performed under systemic heparinisation with a bolus of 5000 IU, followed by hourly bolus injections of 2500 IU with ACT maintaining more than twice the control value. Diagnostic angiograms were obtained for optimal projec-

tions for viewing the neck of the aneurysm and for making baseline observations of leptomeningeal anastomoses.

A guiding catheter (Fasguide, Boston Scientific, USA) was placed in the larger vertebral artery (VA) and a Sentry balloon (3.5 mm x 15 mm) (Boston Scientific, USA) was passed through the guiding catheter and placed in the P2 segment proximal to the aneurysm. The balloon was inflated manually with 0.1 ml of non-ionic iodinated contrast medium to achieve total occlusion of the PCA. Occlusion was maintained for a period of 30 minutes. The patients' tolerance for the PCA occlusion was tested clinically by visual confrontation test. Internal carotid artery (ICA) and vertebral artery angiograms were obtained in all the three patients who had balloon occlusion tests. The patients maintained their blood pressures at their normal level spontaneously. Angiograms were repeated after 15 minutes and 30 minutes after balloon occlusion. Vertebral and carotid injections were done each time, with the acquisition of late views, to evaluate the anatomy of the leptomeningeal collateral supply distal to the P2 occlusion, which arose mainly from choroidal and middle cerebral arteries on the same side. The leptomeningeal collateral supply was judged adequate when the distal PCA territory was supplied, as determined with control ca-

Table 1 Clinical, angiographic and treatment profile of patients with P2-P3 aneurysms

N.	Age	Sex	H&H grade	Fisher's grade	Side	Size of aneurysm in mm	Ictus	Test occlusion	Therapy	Complication	Follow-up / outcome
1	45	M	II	III	Lt	5.9 x 5.2 x 9.5	4 days	Retrograde filling through MCA collaterals	GDC coiling	-----	Left occipital infarct with right superior quadrantanopia
2	38	M	III	IV	Lt	12 x 10.2 x 7.3	6 days	Retrograde filling through MCA collaterals	-----	Aneurysm rupture	Mortality
3	42	F	II	III	Lt	7.45 x 7.15 x 8.69	7 days	Retrograde filling through MCA collaterals	GDC coiling	Distal embolism	No deficit
4	45	M	III	III	Rt	11.2 x 9.3 x 11	8 days	No test occlusion	GDC coiling	-----	Bilateral occipital infarct (R>L) with left superior quadrantanopia

rotid injection on early and late views. Balloon occlusion test was not done in the fourth patient due to adverse results of such occlusion in the third patient.

When the test occlusion did not reveal any clinical deficit or when the leptomeningeal anastomotic network was judged adequate, the patient was put under GA. A microcatheter (Tracker-10; Target Therapeutics, Boston Scientific, Fremont, USA) was advanced through the guiding catheter and placed in the aneurysm close to the distal segment of the PCA arising from the aneurysm. The distal post-aneurysmal PCA was occluded initially, followed by the aneurysmal sac and the proximal pre-aneurysmal PCA finally. Three aneurysms were treated with GDC coils (Target Therapeutics, Boston Scientific, Fremont, USA) so as to completely occlude the aneurysm and the PCA. After post-procedure control angiograms, the patients were clinically examined for visual or sensorimotor deficits. Systemic anticoagulation was continued to maintain ACT at twice the control level for the subsequent 48 h.

Results

Endovascular aneurysm coiling was successful in three cases (table). One patient deteriorated immediately after the balloon occlusion test and subsequently expired. Headaches resolved in all the treated cases.

One patient had fetal PCoA. Balloon occlusion test was done in three patients and demonstrated good collateral filling of the distal PCA territory in all. The distal PCAs received collateral supply from the posterior lateral choroidal and temporal branches of the middle cerebral arteries. One aneurysm ruptured immediately after deflation of the balloon and the procedure was terminated. The aneurysms were completely occluded in the three other cases.

Case Illustrations

Case 1

A 45-year-old man presented with sudden onset of headache, vomiting, and one episode of loss of consciousness. On examination he was drowsy with neck rigidity and GCS of 13/15, with normal fundus. Biochemical and haematological investigations were normal. CT scan showed hyperdensity in left ambient cistern with a prominent vessel passing to the left

temporal region, evidence of SAH and dilatation of lateral and third ventricles. DSA showed a left P2 segment wide-necked saccular aneurysm, with multiple lobes with fundus directed superomedially and measuring 5.9 x 5.2 x 9.5 mm (figure 1A,B). Balloon occlusion test showed patent PCom A and collaterals of MCA supplying the left occipital region (figure 1C,D,E,F,G,H). Endovascular coiling was performed under GA. Check angiogram showed complete aneurysm coiling with distal PCA cut off (figure 1I,J).

Post procedure hypervolemic therapy was given and CT scan showed left occipital infarct. At three month follow-up the patient had right superior homonymous quadrantanopia with bilateral visual acuity of 6/9.

Case 2

A 38-year-old man presented with a two day history of sudden onset headache with doubtful seizure and right-sided weakness. On examination he was drowsy with GCS of 14/15 and mild right hemiparesis. There was no neck stiffness and fundus was normal. CT scan showed diffuse SAH with dilated lateral and third ventricles (figure 2A,B,C). DSA showed a large 12 x 10.2 x 7.3 mm narrow-necked irregular aneurysm arising from the left P2 segment, with the fundus directed inferomedially. The aneurysm filled with both vertebral artery (VA) (figure 2F,G) and left ICA injections (figure 2D,E). Balloon occlusion test was performed just proximal to the aneurysm (figure 2J,K). Diagnostic angiogram of the left ICA aneurysm showed retrograde filling of the PCA and aneurysm through left MCA collaterals (figure 2L,M,N,O). Soon after deflation, the patient developed severe hypertension (BP-220/115 mm of Hg) followed by severe hypotension (BP-40/15 mm of Hg) over the next 15 minutes. Check angiogram under ionotropic support showed severe spasm of the vertebrobasilar trunk. Repeat angiogram after intra-arterial injection of 300 mg of diluted Papavarine showed opacification of the left and right VA with retrograde opacification of the left ICA (figure 2P,Q). None of the major branches of the intracranial circulation were opacified (figure 2P,Q). Repeat CT scan showed diffuse SAH extending up to cerebral convexities (figure 2R). The patient succumbed within 24 h of the procedure. Clinical autopsy was refused.

Figure 1 Towne's view (A) and lateral view (B). Vertebral angiogram shows saccular aneurysm arising from left P2 segment. Towne's view (C) and lateral view (D) shows inflated balloon in P-1 segment of left PCA. Late arterial (E,F) and capillary (G,H) phases of left ICA injection shows delayed collateral supply of occipital region from left MCA branches. Towne's view (I) and lateral view (J). Post coiling vertebral angiogram shows total occlusion of the aneurysm and the left PCA and its branches beyond the aneurysm.

Figure 2 CT scan non-enhanced (A), contrast enhanced (B) with CT angiogram (coronal reconstruction) (C) done six days after ictus shows a giant partially thrombosed left PCA aneurysm with obstructive hydrocephalus and left thalamic infarct.

Figure 2 Towne's view (D) and lateral view (E). Left carotid angiogram shows an aneurysm filling from the left fetal PCA artery directed inferiorly and posteriorly.

Figure 2 Towne's view (F) and lateral view (G). Left vertebral angiogram shows left P2 segment aneurysm.

Figure 2 Towne's view (H) and lateral view (I). Left vertebral angiogram with left carotid compression shows filling of the left ICA through the left PCoA.

Figure 2 Towne's view (J) and lateral view (K) shows inflated balloon in the P-1 segment of left PCA with left ICA angiogram.

Figure 3 Towne's view (A) and lateral view (B). Vertebral angiogram shows saccular aneurysm arising from left P2 segment.

Figure 3 Towne's view (C) and lateral view (D) shows inflated balloon in P-1 segment of left PCA with left ICA angiogram.

Figure 3 Late arterial (E, F) and capillary (G, H) phases of left ICA injection shows delayed pial collateral supply of occipital region from left MCA branches.

Figure 3 Towne's view (I) and lateral view (J). Post coiling vertebral angiogram showing partial filling of left PCA branches beyond the occluded aneurysm.

Figure 3 Post coiling non-enhanced CT scan (K) shows right cerebellar infarct.

Case 3

A 42-year-old female presented with a history of sudden onset of headache and neck pain for two days. On examination she was conscious with GCS of 15/15 and with neck rigidity. CT scan showed the presence of a left temporal bleed with diffuse SAH and communicating hydrocephalus. Intervention was done after ventriculoperitoneal shunt for the hydrocephalus. DSA showed the presence of a left P2 segment aneurysm with fundus directed inferiorly, posteriorly and laterally (figure 3A,B). Balloon occlusion test was performed just proximal to the aneurysm (figure 3C,D). Diagnostic angiogram through the left ICA showed retrograde filling of PCA and aneurysm through left MCA collaterals (figure 3E,F,G,H). Check angiogram after coiling showed total aneurysmal occlusion (figure 3I,J) with delayed distal runoff. Post coiling CT scan was normal (figure 3K).

Case 4

A 45-year-old man presented with a two day history of sudden onset of headache, neck pain

and left-sided weakness. He had partial right third nerve palsy on examination. CT scan showed partially thrombosed aneurysm in right ambient cistern with focal blood clot in the interpeduncular and right ambient cistern. MRI showed partially thrombosed aneurysm in the right ambient cistern with flow artifact, compressing the midbrain (figure 4A,B). DSA showed 11.2x9.3x11 mm sized saccular aneurysm arising from the right P2 segment with a narrow neck and fundus directed posteriorly, inferiorly and medially, filling through the VA injection (figure 4C,D) but not with carotid injections (figure 4E,F). Post coiling check angiogram revealed complete occlusion of the aneurysm with total block of PCA beyond aneurysm (figure 4G,H,I,J). Rt. ICA injection showed delayed collateral filling of the PCA territory through MCA collaterals (figure 4K,L,M,N). Post procedure CT revealed bilateral occipital lobe infarct (figure 4O).

The patient was treated with anticoagulants and hypervolemia. At discharge, the patient had left superior homonymous quadrantanopia.

Figure 4 Towne's view (G, H) and lateral view (I, J). Post-coiling vertebral angiogram showing coils in the aneurysm with complete occlusion.

Figure 4 Late arterial (K, L) and capillary (M, N) phases of right ICA injection shows delayed pial collateral supply of occipital region from right MCA branches. The aneurysm has been totally excluded from circulation.

Figure 4 Post-coiling CT scan (O) showing infarction in both occipital lobes.

Discussion

The PCA belongs to the internal carotid artery (ICA) system and constitutes its caudal terminal branch. The P2 segment represents the first segment of the true PCA system formed by P2, P3, and P4 segments⁹.

The upper basilar artery distal to the trigeminal artery remnant, the P1 segment of the PCA and the PCoA, are included in this system. Embryologically, the PCA is a diencephalomesencephalic artery, which gathers its telencephalic supply by the distal annexation of the anterior choroidal artery (AChA) territory⁸. In the so-called normal adult pattern, the P1 segment is larger than the PCoA. In the fetal-type configuration of the PCA, which is observed in as many as one third of cases undergoing cerebral angiogram, the PCA arises directly from the ICA¹¹ and the diameter of the P1 segment is smaller than that of the PCoA. Zeal and Rhoton¹² reported that the P1 segment in the fetal type is slightly longer than the P1 segment in the adult type.

The PCA has been divided anatomically into three⁶ or more commonly four segments¹². The P2 segment begins at the PCoA-PCA junction and courses within the distal peduncular and the ambient cisterns to end at the posterior part of the midbrain. It can be further subdivided into two parts, each 25 mm long. The anterior half, P2A, courses around the cerebral peduncle, inferior to the optic tract and basal vein of Rosenthal and medial to the hippocampus to enter the proximal portion of the ambient cistern. The posterior half, P2P, begins at the posterior margin of the cerebral peduncle, courses along the posterolateral midbrain, parallel and inferior to the basal vein and optic tract, inferolateral to the geniculate bodies and pulvinar, and superomedial to the trochlear nerve and tentorial edge; P2P ends at its entrance into the quadrigeminal cistern. On anatomic specimens, the average diameter of the P2 segment is 2.9 mm, which allows endovascular navigation¹². The P2 segment has three types of branches: first, the central branches to the brain stem, second, the ventricular branches and third, the inferior temporal cortical branches.

PCA aneurysms are unusual, accounting for approximately 1% of all intracranial aneurysms. Although Drake and Amacher⁴ reported that the most common site of origin for PCA aneu-

rysms is the first major branching point beyond the junction with the PCoA, the aneurysms may occur at any branch origin along the course of the main trunk of the PCA. According to the PCA segment involved, the aneurysms are classified as those of the P1 segment, the P1-PCoA junction, the P2 segment, the P3 segment, or the P4 segment. Aneurysms of the P2 segment have been reported either as single cases or as part of general reviews of vertebrobasilar aneurysms. Terasaka et al¹³ presented a surgical series of 14 aneurysms in the P2 segment. Most of P2 aneurysms are saccular, arising at the origins of its central or cortical branches, but fusiform and serpentine forms have also been reported^{14,15}. Clinically, P2 segment aneurysms present as SAH¹⁶, tumoral mass effect or ischemic stroke in the thalamic territory¹⁷. They can also present with headaches and visual field defects⁴. Aneurysmal formation has been related to increased flow in the PCoA with fetal type PCA¹⁸. Case two in our series had fetal type PCA.

Direct interventions for aneurysms of the posterior circulation are more difficult than are those for aneurysms of the anterior circle of Willis. However, PCA aneurysms of P2, P3, and P4 segments¹⁹ do not pose the same technical difficulties, nor do they have the same prognosis as that of basilar or P1 segment aneurysms. Surgical treatments differ, depending on the type of aneurysm (i.e., berry or saccular, fusiform, or serpentine). For saccular aneurysms, even for giant ones, complete occlusion of the sac and neck can be attempted by placing clips in the aneurysmal necks. However, clip placement in the neck may sometimes be difficult or hazardous.

Other surgical options available are clip placement in the proximal artery, excision of the aneurysmal sac without or with the restoration of distal flow via direct anastomosis or bypass, and use of a trapping procedure^{2,5,6}.

Endovascular treatment is not associated with manipulation of the surrounding tissues. Therefore, the risks of major brain damage due to retraction or removal are theoretically reduced. However, specific thromboembolic events could be a problem as was seen in our patients. Two patients (cases one & four) developed homonymous hemianopia after the procedure, similar to the reports of Lazinski et al²⁰. One patient (case three) had multiple small infarcts in the

PCA territory without clinical deficits. This was not anticipated as pre-embolization balloon occlusion test done prior to coiling showed adequate collateral filling of the distal circulation of the occluded PCA territories (figure 1 and 4). This may suggest that visualization of distal PCA circulation on balloon occlusion may not be an insurance against visual loss after coiling. In addition, an aneurysm ruptured with fatal outcome in one patient soon after the occluding balloon was deflated.

There are many possible contributory factors for adverse outcome in our group of patients and include haemodynamic, instrumental, thromboembolic or technical. Sudden changes in local haemodynamics due to deflation of the balloon, perforation of the artery or the aneurysm or rupture of an unrecognized dissected portion of P2 segment by instruments including the intravascular balloon could be some of the causes.

Three of the four aneurysms in our series were partially thrombosed and thromboembolic events occurred in our patients in spite of prophylactic anticoagulation during and after the procedure. In view of the presence of large amounts of thrombus in P2 aneurysms, it may be necessary to consider the importance of technical strategy in preventing the release of thromboembolic material during the procedure. This may be achieved by avoiding manipulation of the coils during the procedure. While perfusion studies with balloon occlusion may provide the necessary prognostic information regarding visual cortical viability, it seems impractical and may be superfluous. Of the three patients of Yamashita et al who tolerated aneurysmal occlusion, two had transient ischemic attacks²¹. Our experience would also suggest balloon occlusion test in P2 aneurysms may be not

only unnecessary but also sometimes dangerous. Homonymous hemianopia seems to be an acceptable risk for complete aneurysmal cure.

Real-time angiography allowed us to evaluate the anastomotic supply to the desired occlusion point. In our series, test occlusion was done in three patients. As one patient had an aneurysmal rupture after a trial of balloon occlusion, the fourth patient was successfully treated without the balloon occlusion test. Analysis of their angiograms showed, after the point of occlusion, the unoccluded posterior temporal and occipital branches behave as sump aspirators for anastomotic flow, allowing revascularization of the distal PCA via leptomeningeal collaterals. This finding was also noted in five cases in the series of L. Ferrante et Al¹. It is surprising that neurological deficits are still possible after such excellent clinical and angiographic control.

Conclusions

In our small series of four patients, P2 segment aneurysm coiling was curative, regardless of whether the location was proximal or distal to the perforating, ventricular, or cortical branches. Our experience would also suggest balloon occlusion test in P2 aneurysms may be not only unnecessary but also sometimes dangerous. While, the potential for collateral supply and the haemodynamic balance between the vascular territories may preclude serious complications with parent artery occlusion, cerebral ischemic events frequently occur in the distal PCA territory. Hence, treatment of P2 aneurysms without prior balloon occlusion test is recommended. It is also suggested that the routine technique of manipulation of the coils during placement in the aneurysm be avoided.

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