Treatment and outcome in 30 patients with posterior cerebral artery aneurysms

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Object. The records of 30 patients with posterior cerebral artery (PCA) aneurysms treated during a 12-year period were reviewed to determine outcome and the risk of visual field deficit associated with PCA sacrifice.

Methods. Clinical data and treatment summaries for all patients were maintained in an electronic database. The Glasgow Outcome Scale (GOS) and modified Rankin Scale (mRS) scores were determined by an independent registrar. Visual field changes were determined by review of medical records. Twenty-eight patients were treated with open surgery, one of them after an attempt at detachable coil embolization failed. Two patients underwent successful endovascular PCA sacrifice.

The mean GOS and mRS scores in 18 patients with unruptured aneurysms were 4 and 2, respectively, at discharge. Subarachnoid hemorrhage (SAH) from other aneurysms and neurological deficits caused by the PCA lesion or underlying disease contributed to poor outcomes in this group. The mean GOS and mRS scores in 12 patients with ruptured aneurysms were 4 and 4, respectively, at discharge. One patient died of severe vasospasm. Neurological deficits secondary to and, in one patient, treatment of a concomitant arteriovenous malformation contributed to poor outcomes in the patients with ruptured aneurysms. Seven patients with normal visual function preoperatively underwent PCA occlusion. One patient (14%) developed a new visual field deficit.

Conclusions. Optimal treatment of PCA aneurysms is performed via one of several surgical approaches or by endovascular therapy. The approach is determined, in part, by the anatomical location and size of the aneurysm and the presence of underlying disease and neurological deficits.

KEY WORDS • cerebral aneurysm • subarachnoid hemorrhage • posterior cerebral artery • microsurgery • endovascular therapy • treatment outcome

Aneurysms may involve any portion of the PCA from its origin at the BA terminus in the interpeduncular cistern through its distal branches that supply the occipital lobe. Like aneurysms in other locations, PCA lesions may be saccular or fusiform. They may present with SAH or with neurological deficits from mass effect or distal embolization. Aneurysms of the PCA are, however, much less common than those in other locations. A variety of treatment options exist, depending on the location of the aneurysm on the PCA and its association with perforating branches. In addition, because the PCA supplies the visual cortex, treatment options may be influenced by the patient’s preoperative visual function and the presence or absence of collateral blood supply to this region.

The anatomy of the PCA and various surgical or endovascular approaches to aneurysms of the PCA have been described. This review was conducted primarily to answer two questions: 1) what is the outcome of patients with PCA aneurysms as measured by the GOS and mRS scores, and 2) what is the risk of visual field deficits associated with PCA sacrifice?

Clinical Material and Methods

Aneurysm Database

A standardized form has been used to record clinical data and summaries for all patients with cerebral aneurysms treated at Zale-Lipshy University Hospital at Southwestern Medical Center in Dallas, Texas, since January 1, 1990. This information is maintained in the STAR database. Recorded data include unique identifiers, sex, age, and information on the patient’s preoperative condition. Data regarding the admission assessment include Hunt and Hess grade, American Society of Anesthesiologists grade, CT results, and angiographic findings. Microvascular or endovascular treatment data are summarized. The GOS score at discharge, 6 months, and 1 year is determined through telephone contact and hospital and clinic chart review by an independent registrar.

According to convention, we report the GOS score as follows: 5, good recovery (patient can lead a full and independent life with or without minimal neurological deficits); 4, moderately disabled (patient has neurological or intellectu-
al impairment but is independent); 3, severely disabled (patient is conscious but dependent on others to get through the activities of the day); 2, vegetative survival (no obvious cortical function); and 1, death. The mRS scores are defined as follows: 0, no symptoms at all; 1, minor symptoms that do not interfere with lifestyle; 2, minor handicap (symptoms that lead to some restriction in lifestyle but do not interfere with patients’ capacity to look after themselves); 3, moderate handicap (symptoms that significantly restrict lifestyle and prevent totally independent existence); 4, moderately severe handicap (symptoms that clearly prevent independent existence although not needing constant attention); 5, severe handicap (patient is totally dependent, requiring constant attention night and day); and 6, death.

A search of the STAR database was performed to identify patients in whom a PCA aneurysm had been diagnosed. All available hospital and clinic charts for these patients were reviewed for details of clinical presentation, treatment, and outcome. The mRS score at discharge was assigned retrospectively after chart review by the independent registrar. Angiograms were reviewed whenever they were available; however, because our file room keeps angiograms for only 5 years and because some patients were referred from other institutions, the original films were not available in all cases.

Aneurysms were classified as saccular or fusiform according to their appearance at surgery and/or on angiographic studies. Location was classified according to the description by Drake, et al.,14 of four segments of the PCA (illustrated by Fig. 1):

P1 includes the artery from its origin to and including the P1–P2 posterior communicating artery confluence. P2 extends to and includes the first major branching on the side of the midbrain—usually the anterior temporal artery. The next segment up to the origin of the parietooccipital and calcarine arteries is called P3 and the most distal part P4.

Aneurysms that were 20 mm or larger in their greatest diameter were classified as giant.

Patient Population

Thirty patients with aneurysms of the PCA were treated at Zale-Lipsy University Hospital between January 1, 1990, and January 30, 2002 (Table 1). The male/female ratio was 2:3 and the mean age was 46 years (range 9–73 years). Multiple aneurysms were present in 10 (33%) of 30 patients. A total of 47 lesions, including 32 PCA aneurysms, were recorded in the study group (Fig. 2). A patient with bilateral P1/P2 junction aneurysms also harbored a lesion in the PCoA. A saccular aneurysm of the PCA that was feeding a parietal AVM in one patient was identified; no other vascular malformations were found. Only two patients had an ipsilateral fetal origin of the PCA; one occurred in a patient with a ruptured P1/P2 junction aneurysm and a hypoplastic P1 segment, the other in association with an unruptured 3-mm P3 segment aneurysm. One patient with bilateral ICA occlusion secondary to atherosclerotic disease had retrograde filling of both PCoAs supplying her anterior circulation. This was associated with a saccular aneurysm of the P1/P2 junction. A patient with Ehlers–Danlos syndrome had previously undergone bilateral surgical ICA occlusion for treatment of anterior circulation aneurysms; he presented with a fusiform lesion of the P1/P2 junction.

Results

Unruptured Aneurysms

There were 19 unruptured PCA aneurysms in seven men
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and 11 women; one patient harbored bilateral P1 segment lesions. The mean age of these patients was 48 years (range 20–73 years). Fifteen of 19 aneurysms were asymptomatic; two of these were treated when the patient presented with SAH from another aneurysm and three were treated 2 to 5 months after SAH from another aneurysm. Of the four symptomatic unruptured lesions, two presented with cranial nerve palsies, one with major mass effect, and one with distal embolism.

Third cranial nerve palsy was seen in two patients at presentation. One, a 30-year-old woman with a giant saccular aneurysm in the P1 segment, had a complete third nerve palsy. The second patient, who had an irregular, lobulated 5 × 12-mm aneurysm of the P2 segment, presented with intermittent diplopia.

Three patients experienced visual field deficits prior to surgical treatment. Loss of vision was the presenting symptom in a 54-year-old woman with a giant left P1/P2 junction saccular aneurysm. Visual field testing revealed a homonymous right inferior quadrant defect that was likely the result of emboli from her aneurysm being deposited in the left occipital lobe. Her visual field deficit was stable after surgical repair of the lesion. The second patient with a visual field deficit at presentation was a 20-year-old man with probable Ehlers–Danlos syndrome who presented with right-sided body numbness. He had previously undergone bilateral ICA occlusions for cavernous CA aneurysms. At presentation he was blind in the left eye and had partial visual loss in the right eye. Endovascular occlusion of his PCA for treatment of a 1 × 1.5-cm fusiform aneurysm of the left P1/P2 junction resulted in mild numbness of the lips and fingertips that had nearly resolved at the time of discharge. No change in his severely limited visual function was detected on postsurgical testing. One patient presented with mass effect resulting in contralateral homonymous hemianopsia.

The unruptured aneurysms consisted of 15 saccular and four fusiform lesions. Seven saccular aneurysms (two giant) occurred at the P1/P2 junction. Three of these lesions occurred on the P1 segment (bilateral P1 aneurysms in one patient, giant P1 lesion in another); two on the P2 segment (one giant); one at the P1/P2 junction; and one on the P2 segment. The parent segment of the PCA was not recorded for one saccular aneurysme. One fusiform aneurysm occurred at the P1/P2 junction, one on the P2 segment (giant), and one involved both P1 and P2 segments. The location was not specified for the other giant fusiform aneurysm.

The GOS score at discharge in the 18 patients with unruptured aneurysms averaged 4 (range 3–5, Table 2); the mRS score at discharge in these patients averaged 2. There were no deaths, although a poor outcome (GOS Score 3; mRS Score 4 or 5) occurred in two patients. The first was a 57-year-old man who was transferred to our institution after surgery for an unruptured giant aneurysm on the left P1 segment was complicated by aphasia and right hemiparesis. He had no new deficits after surgery at University of Texas Southwestern. There was no change in his visual field deficit. His surgery was complicated by otorrhea that was adequately treated with 4 days of lumbar drainage.

Two patients were lost to follow up. In the 16 patients for whom follow-up assessments were available, three had good recovery (GOS Score 5) at discharge and remained in good condition at the 1-year follow up. Five moderately disabled patients (GOS Score 4) improved to good recovery, whereas four others with GOS Score 4 remained stable. One severely disabled patient (GOS Score 3) improved to moderate disability, whereas one other with GOS Score 3 remained stable at 1 year. Two patients treated less than 12 months before the end of this study were discharged in good condition (GOS Score 5) and remained stable at the 6-month follow-up review.

Ruptured Aneurysms

Five male and seven female patients presented after rupture of a PCA aneurysm. One of these patients harbored bilateral P1/P2 junction aneurysms, for a total of 13 PCA lesions. The mean age in this group of patients was 45 years (range 9–60 years). Four were categorized in Hunt and Hess Grade II and seven were Grade III at the time of admission. None of these patients exhibited a third nerve palsy, visual field deficit, or hemiparesis at the time of presentation. Another patient was a 64-year-old man who was treated 13 months after SAH and 7 months after detachable coil embolization at another institution (Fig. 3). The embolization procedure had been complicated by cerebral infarction with dense hemiparesis. Subsequent angiography demonstrated continued enlargement of his giant P1/P2 junction aneurysm, prompting his referral for surgical treatment.

The ruptured aneurysms included 11 saccular and two fu-
siform lesions. Seven saccular aneurysms (one giant), including the bilateral aneurysms described earlier, occurred at the P1/P2 junction; two were located on the P2 segment; one at the P2/P3 junction (giant); and one on the P3 segment. The two fusiform aneurysms were located on the P4 segment. One of these was described as having a “mycotic appearance;” however, the patient did not have subacute bacterial endocarditis or evidence of sepsis.

The GOS score at discharge averaged 4, including one death (GOS score range 1–5, Table 2), in patients with ruptured aneurysms. The mRS score at discharge in these 12 patients averaged 4. The death occurred in a 60-year-old woman with a saccular aneurysm of the right P1/P2 junction who was categorized in Hunt and Hess Grade III at presentation. Her underlying medical conditions included congestive heart failure, bilateral CA occlusion, and obesity. The patient underwent frontotemporal, transsylvian exposure of her aneurysm. After induction of a barbiturate coma, temporary clip trapping was performed for a total of 5 minutes. On postoperative Day 7 she experienced left hemiparesis. An angiogram obtained at that time did not reveal vasospasm, and she was treated with hypertension, hypervolemia, and hemodilution therapy. An angiogram obtained on postoperative Day 10 demonstrated vasospasm in the right P1 segment of the PCA and she was treated with intraarterial papaverine. Despite treatment, she suffered multiple infarctions and died on postoperative Day 16.

Two patients who were discharged in good condition (GOS Score 5) remained stable after 1 year; however, one patient who was discharged in good condition had moderate disability (GOS Score 4) at 6 months and 1 year. In this 47-year-old woman, endovascular treatment of a P2 segment aneurysm on a feeding vessel of a parietal AVM failed. She remained neurologically intact with no visual field deficit after temporoparietal craniotomy and a middle temporal gyrus approach with PCA sacrifice. One month later she underwent endovascular embolization of the AVM, followed by craniotomy for removal of the lesion. Immediately after surgery she was returned to the operating room for removal of a 2 × 2-cm hematoma in the operative bed. She underwent repeated operation for hematoma on postoperative Days 5 and 7. She is now moderately disabled by a left hemiparesis. Five patients were discharged with moderate disability (GOS Score 4); two improved to good condition and two patients remained stable. One patient with moderate disability at discharge with moderate disability was lost...
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to follow up (according to Social Security records he died 6 years and 8 months after discharge). Three patients had severe disability (GOS Score 3) at discharge; all improved to moderate disability at 6 months and two improved to good recovery at 1 year.

**Surgical Approach**

In 15 operations for 17 aneurysms of the P1 segment or P1/P2 junction, the frontotemporal, transsylvian approach was used exclusively. Typically this involved partial resection of the ipsilateral medial temporal lobe. Two aneurysms of the P2 segment were treated via subtemporal, one via frontotemporal, and one (through the middle temporal gyrus) via temporoparietal approaches. One aneurysm of the P2/P3 junction was treated via a frontotemporal approach, whereas the other was approached subtemporally. The subtemporal approach was used for both aneurysms of the P3 segment. A frontotemporal approach was used for successful clip reconstruction of a fusiform aneurysm involving the P3 and P4 segments. Two aneurysms for which the parent segment of the PCA was not identified were treated via the frontotemporal approach.

Transient third nerve palsy and mild contralateral weakness occurred universally after treatment via the pterional approach. In most cases these symptoms resolved while the patient was in the hospital; however, three patients had persistent third cranial nerve weakness at the time of discharge. New contralateral hemiparesis persisted at the time of discharge in five patients after pterional craniotomy and in one after a subtemporal approach. As described earlier, surgery in one patient was complicated by otorrhrea.

We attempted detachable coil embolization in a 47-year-old woman with an unruptured saccular aneurysm of the P3 segment. This procedure, which was performed in January 1995, was complicated by supraclinoid ICA thrombus and middle cerebral artery embolus. The patient subsequently underwent surgery and was moderately disabled at her 1-year follow up. Detachable coil embolization was successful for PCA sacrifice in two patients with fusiform aneurysms treated at our institution. One was the young man with Ehlers–Danlos syndrome described earlier. The second patient was a neurologically intact 41-year-old man with a giant fusiform aneurysm of the P3 segment. His vision remained intact after PCA sacrifice (Fig. 4).

Permanent occlusion of the PCA occurred with treatment in nine patients. Two patients had preoperative visual field deficits, including the one with Ehlers–Danlos syndrome described earlier and a 33-year-old woman with a ruptured mycotic-appearing aneurysm of the P3 segment. Before her operation she suffered from a complete homonymous hemianopsia. She underwent surgery via a posterior interhemispheric approach and subsequently experienced occipital lobe infarction and edema that required a second operation for debridement. In seven patients with intact vision, PCA sacrifice resulted in one new visual field deficit (14%). This occurred in a 50-year-old man who presented in Hunt and Hess Grade II from a ruptured fusiform aneurysm of the right P1 segment. He underwent surgery via a subtemporal approach that included inferior temporal gyrus resection. Two perforating vessels were seen to emerge from the aneurysm. Postoperatively he suffered from a homonymous left upper quadrant visual field deficit.

**Discussion**

In 1964, Schaeffer reported the literature and found 18 individually reported cases of PCA aneurysms. The first report was published in 1928, and it described an aneurysm that was found at autopsy, as were the majority of the reported cases until the 1960s. Schaeffer noted that the prevalence of PCA aneurysms might have been underestimated because VA angiography was not routinely performed after SAH during the time period studied. He also noted that some authors excluded PCA lesions from the discussion of posterior circulation aneurysms because “they are not . . . situated in the posterior fossa.” Schaeffer reported two cases of his own and described a variety of treatment options, including VA ligation, aneurysm trapping, and proximal ligation of either the PCA or PCoA.

In 1969, Drake and Amacher reported on eight patients with PCA aneurysms. Subsequently, Drake, et al., published the largest aneurysm series to date. This impressive compilation included 125 patients with PCA lesions; they accounted for 7% of 1767 patients with vertebrobasilar artery aneurysms treated during a 33-year period. Smaller case series and individual cases have also been reported.

We found that the majority of PCA aneurysms occur on the P1 segment or at the P1/P2 junction. In our study, 17 (53%) of 32 PCA aneurysms were found in these locations. In the series by Drake, et al., 71 (57%) of 125 lesions were located on P1 or at the P1/P2 junction. In contrast, Ferrante, et al., in a report that included seven of their own cases and 79 PCA aneurysms reported in the literature after 1970,
concluded that the P$_2$ segment was the most common location for aneurysms of the PCA.

We treated aneurysms on P$_1$ and at the P/P$_1$ junction uniformly through a frontotemporal, transsylvian craniotomy, usually ipsilateral to the lesion. This approach was favored by Yaşargil, whereas Drake et al. used the subtemporal approach. The primary advantages of the pericallosal approach are early proximal control with isolation of the BA, PCoA, and P$_1$ segment origin, and good visualization of the contralateral PCA to allow temporary trapping, which we use in most cases. Conversely, the subtemporal approach may offer improved visualization of the critical thalamoperforating and peduncular perforating vessels originating from the posterior aspect of the PCA that must be preserved in all cases.

According to the GOS, the outcome was, on average, the same in our patients with ruptured and unruptured aneurysms. There are several reasons for this. 1) The patients with unruptured lesions included five with SAH from another aneurysm. In three of these cases, the PCA aneurysm was treated separately from the ruptured one, either because a separate surgical approach was required or because the patient was referred from another institution. Because these patients were treated 3 to 5 months after SAH, the regimen more closely resembled that for the patients with asymptomatic aneurysms. For this reason they were included in the group with unruptured lesions. Nevertheless, some of these patients did have residual deficits from their hemorrhage. 2) The group with unruptured aneurysms included four symptomatic patients; neither of the patients with preoperative visual field deficit improved after surgery. 3) Several patients in the group with unruptured aneurysms presented with fixed deficits from underlying disease (Ehlers–Danlos syndrome, multiple sclerosis) or after complications from previous treatment. 4) Because the GOS is a “rank-order” scale, only integers (without decimal places) have clinical relevance and validity.

According to the mRS, the outcome at discharge was better in patients with unruptured aneurysms than in those whose lesions had bled. The STAR database includes patients treated since January 1, 1990. The mRS was published in 1988, however, this scale was not included in the STAR database at the time of its design. Because our study included patients treated more than 10 years ago, the mRS scores were assigned on the basis of chart review alone. These scores were determined only for the time of discharge, because that is the time when information in the medical record is most complete. It was not our intention to compare the many outcome scales developed for patients with stroke in this small group of patients with SAH.

We had one case of postoperative visual field deficit in seven patients whose vision was intact preoperatively and who underwent PCA sacrifice. In this patient (described earlier) the field cut can be attributed to the surgical approach. Yaşargil cited angiographic evidence of leptomeningeal collateral vessels or brisk back-bleeding from the distal PCA as evidence that patients would tolerate PCA occlusion. Nonetheless, postoperative deficits do occur after PCA sacrifice and may cause significant morbidity. Hunt and Hess described homonymous hemianopsia and hemiparesis after trapping of a large PCA aneurysm. The hemianopsia resolved by postoperative Day 5 and the hemiparesis was resolved at postoperative Day 10. Chang, et al. reported on 10 patients with PCA aneurysms; four lesions were treated with trapping. In their first two patients, postoperative homonymous hemianopsia and hemiparesis occurred (permanently in one and transiently in the other). Neither of these patients was treated with a bypass procedure. Their third patient underwent excision of a P$_1$ segment aneurysm with end-to-end anastomosis of the residual vessel; postoperatively he had no visual field deficit. Their fourth patient underwent trapping of a P$_1$ segment aneurysm and an STA–PCA bypass; he was also spared a visual field deficit. These authors advocated “. . . PCA revascularization, if the anastomosis can be safely performed without additional operative risk, . . . when treating unclippable (PCA) aneurysms. . . .”

Gerber and Neil-Dwyer reported PCA sacrifice in six patients. In one patient a partial homonymous hemianopsia developed after surgery; this condition had completely resolved at 12 months. These authors made the unique observation that, in three patients with homonymous hemianopsia preoperatively, the visual deficit either resolved completely or improved after proximal clip occlusion of the PCA. Hallacq, et al. reported performing nine endovascular PCA sacrifices in 10 patients with PCA aneurysms of the P$_1$ segment. None of the patients experienced new visual field deficits or any other complications, and the authors advocate this treatment. Drake, et al. performed PCA occlusion or aneurysm trapping in 52 patients (42%). Five of these patients had either preoperative visual field deficits or unknown outcomes. Of the remaining 47 patients, new postoperative visual field deficits developed in five (11%). When the P$_1$ segment aneurysms were excluded and only occlusion or trapping beyond the PCoA was considered, however, the risk of a new visual field deficit was 17%.

Trial endovascular balloon occlusion is commonly performed prior to permanent sacrifice of the ICA, VA, or BA. With the availability of small, flexible, nondetachable balloons, this procedure may be used to estimate individual patient response to PCA occlusion. Hallacq, et al. used trial balloon occlusion in five of their patients, one of whom was awakened for neurological testing, whereas in four patients the evidence of collateral vessels from VA or CA injections was considered adequate.

Since completing this study, we have performed trial balloon occlusion of the PCA in one patient who had a fusiform aneurysm distal to the left PCoA. In this patient a central scotoma developed after 14 minutes of occlusion, prompting early termination of the test. A corresponding area of reduced perfusion was identified on the postocclusion single-photon emission CT scan. Based on the anatomy of the aneurysm and the patient’s medical condition, he underwent trapping of the lesion without concomitant bypass. Postoperatively a complete right homonymous hemianopsia developed. Because of limited published experience, however, the predictive value of this test in the PCA has not been established. When interpreting neurological deficits produced during temporary balloon occlusion of the PCA, it is important to differentiate between the effects of direct perforating vessel occlusion and those of interruption of anastomotic PCA blood flow. At our institution, single-photon emission CT scanning is used in conjunction with the neurological examination to determine the results of trial artery occlusion.

When anatomical studies and/or trial balloon occlusion
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indicate dependence on antegrade flow in the PCA, a bypass procedure may be considered. Options for PCA revascularization have been thoroughly described and include STA–PCA anastomosis, occipital artery–PCA anastomosis, or a bypass from the extracranial great vessels to the PCA with saphenous vein or radial artery grafting. An STA–posterior temporal artery bypass has also been described. All of these procedures require temporary occlusion of the recipient PCA and, therefore, there is a risk of occipital infarction in patients who are dependent on antegrade PCA flow. Nonocclusive bypass to the P1 segment of the PCA by using excimer laser assistance has been described and may significantly decrease this risk.

Conclusions

Aneurysms of the PCA are interesting for reasons that include their relative rarity and the variety of approaches that may be used for their successful treatment. Although patients can be treated without causing new neurological deficits or other morbidity, many patients with these lesions are left with some degree of dysfunction caused by either hemorrhage from the aneurysm, the complications associated with hemorrhage, cranial nerve palsy, embolism, or mass effect. In any case, when treatment is contemplated, all reasonable methods to reduce the risk of associated morbidity should be considered. The one new visual field deficit in our series might reasonably be explained by the surgical approach used, which placed the ventral fibers of the optic radiation at risk. Because only a low risk to the visual fields after PCA sacrifice has been reported in other series, it might be concluded that the procedure may be used without reservation. Nevertheless, the experience of Drake, et al., in which a new visual deficit developed in 17% of patients undergoing PCA sacrifice beyond the PCoA encourages development and use of PCA trial balloon occlusion as a diagnostic tool prior to permanent sacrifice. Also, safe methods must be found to bypass into the PCA when sacrifice is needed.

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