Fetal-type posterior cerebral artery: the pitfall of parent artery occlusion for ruptured P₂ segment and distal aneurysms

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OBJECT P₂ segment and distal aneurysms are rare lesions of the cerebrovascular system. The efficacy and safety of endovascular occlusion for these types of aneurysms remain controversial. The aim of this study was to reveal risk factors for endovascular parent artery occlusion of ruptured P₂ segment and distal aneurysms.

METHODS Between March 2010 and November 2012, 812 patients with a ruptured intracranial aneurysm were admitted to the authors' hospital. Among them, 11 patients presented with P₂ segment and distal posterior cerebral artery (PCA) aneurysms. These patients were subjected to endovascular treatment. Periprocedural data and clinical and angiographic records were studied retrospectively.

RESULTS Of the patients with a ruptured PCA aneurysm, 2 of them underwent selective aneurysmal coiling, and the remaining patients were treated with simultaneous occlusion of the parent artery. Patients with an adult-type PCA (n = 6), treated with either selective coiling or simultaneous parent artery occlusion, had no serious neurological deficits on follow-up. Four patients with a fetal-type PCA that was also occluded intraoperatively exhibited newly developed permanent paralysis and hemianopsia. However, 1 patient with a fetal-type PCA aneurysm that was selectively coiled recovered without complications. No recanalization was observed in any of the treated aneurysms.

CONCLUSIONS Endovascular occlusion of an aneurysm and its parent artery is a safe and effective method for managing adult-type P₂ segment and distal aneurysms. However, the authors' clinical data suggest that this method is of high risk for patients with fetal-type PCA aneurysms.

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KEY WORDS posterior cerebral artery; aneurysm; spontaneous subarachnoid hemorrhage; fetal-type; parent artery occlusion; coiling; vascular disorders

POSTERIOR cerebral artery (PCA) aneurysms are rare lesions that account for only 0.7%–2.3% of all intracranial aneurysms.^{5,7,10,16,17,19} Because fetal-type PCA is a normal variation of a PCA, with a rate of 3%–36%,²⁰ there is an even lower incidence of fetal-type PCA aneurysms. The term “fetal-type PCA” refers to the condition of the PCA originating directly from the posterior communicating artery (PCoA). In this case, the P₁ segment is

either smaller than the PCoA or has disappeared. Before this study, fetal-type PCA aneurysms have never been reported as an individual group.

Given its complicated anatomical character, surgical management of the PCA aneurysm may be of high risk for the patient and is being replaced gradually by neurointervention. For P₂ segment and distal aneurysms, it is believed that endovascular intervention yields a better clinical out-

ABBREVIATIONS BOT = balloon occlusion test; CTA = CT angiography; DSA = digital subtraction angiography; GOS = Glasgow Outcome Scale; HH = Hunt and Hess; ICA = internal carotid artery; ICH = intracerebral hematoma; IVH = intraventricular hemorrhage; MRA = MR angiography; PAO = parent artery occlusion; PCA = posterior cerebral artery; PCoA = posterior communicating artery; SAH = subarachnoid hemorrhage.

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come than surgical clipping, and even sacrificing the parent artery is safe and effective.^{3,4,6,8,9,12–14,18,21,24} However, in our clinical practice, there are still severe neurological complications in patients who are treated interventionally and have a good preoperative status. In this study, we retrospectively reviewed the neurointerventional cases of P₂ segment and distal PCA aneurysms to evaluate the safety and efficacy of the technique and to analyze the risk factors that lead to poor outcome in these patients.

Methods

Patients

From March 2010 to November 2012, 812 patients suffering from a ruptured intracranial aneurysm were admitted to our hospital (Second Affiliated Hospital of Zhejiang University, School of Medicine, Hangzhou, People's Republic of China). Digital subtraction angiography (DSA) was performed on these patients upon admission, generating a 3D image to confirm the diagnosis. Among them, 11 patients (3 female and 8 male) were diagnosed with P₂ segment and distal PCA aneurysms. The ages of the patients ranged from 36 to 77 years (mean age 55.4 years). Each patient presented with subarachnoid hemorrhage (SAH), and some of them also presented with intraventricular hemorrhage (IVH) (n = 4) or intracerebral hematoma (ICH) (n = 2). One patient (Patient 6) presented with light paralysis in combination with SAH and did not recover. Each patient was evaluated according to the Hunt and Hess (HH) grading scale on admission, which ranged from Grade 1 to 5. Of the 11 patients, 1 (Patient 10) had 2 additional unruptured aneurysms, discovered accidentally at the ipsilateral internal carotid artery (ICA) and M₂ segment, which were untreated and remained stable at the 1-year follow-up. One patient (Patient 6) had a small intracranial arteriovenous

malformation that was embolized during the procedure. The diameters of the ruptured aneurysms ranged from 2.2 to 12.5 mm. Of the 11 parent PCAs, 5 were fetal-type PCAs, as confirmed by DSA. The characteristics of the patients and their aneurysms are summarized in Table 1. All cases are listed in numerical order and are also presented in Figs. 1–11, respectively.

Treatment

Emergency DSA was performed for each patient on admission under general anesthesia. The femoral artery was punctured, and a 6-Fr vascular sheath (Radifocus; Terumo) was placed. Before continuing with any additional procedures, each patient received a heparin bolus of 3000 IU, followed by hourly bolus injections of 1500 IU. The flushing solution also contained heparin.

After conducting angiography of the bilateral internal and external carotid and vertebral arteries, a 6-Fr guiding catheter (Chaperon; Terumo) was advanced into the target vessel. On the basis of the 3D reconstruction image, we decided on a working angle to expose the neck of the aneurysm. The balloon occlusion test (BOT) was not performed before coiling the parent artery. A microcatheter (Excelsior SL-10 [Boston Scientific] or Echelon-10 [ev3]) was further advanced to the aneurysm with the aid of a guidewire (Synchro2 or Transcend; Boston Scientific). Two of the patients underwent selective aneurysm coiling with electrolytically detachable coils (Microvention/Terumo). The other 9 aneurysms were coiled simultaneously with the parent vessel 2 mm proximal to the aneurysm, with or without glue (Onyx18; ev3). After the endovascular procedure, repeat angiography was performed to detect insufficient filling of the branches. Heparin treatment was not reversed. Patients with a newly developed motor deficit

TABLE 1. Clinical data, aneurysm characteristics, and periprocedural data of 11 patients with P₂ and distal aneurysms*

Pt No.†	Age (yrs), Sex	Presentation	Aneurysm Location	Aneurysm Size/Shape	Fetal-Type PCA	Treatment/Material	Complication/Brain Infarction	GOS Score at 1-yr
1	57, M	SAH & IVH	Rt P ₂	Medium/irregular saccular	Yes	PAO/8 coils	Paralysis & hemianopsia/thalamus & rt occipital lobe (major)	3
2	61, M	SAH	Lt P ₂ –P ₃	Medium/fusiform	No	PAO/10 coils	None/lr occipital lobe (minor)	5
3	49, M	SAH & ICH	Rt P ₂	Large/saccular	Yes	SAC subtotal/7 coils	None/none	5
4	57, M	SAH & ICH	Lt P ₂	Large/fusiform	No	PAO/11 coils	None/lr occipital lobe (minor)	5
5	50, M	SAH & IVH	Lt P ₂ –P ₃	Large/saccular	No	PAO/4 coils & Onyx18	None/lr occipital lobe (minor)	5
6	36, M	SAH, IVH, & paralysis	Rt P ₃	Small/saccular	No	PAO/3 coils	None/none	4
7	63, M	SAH & IVH	Lt P ₂	Medium/saccular	No	PAO/6 coils	None/lr occipital lobe (minor)	5
8	46, M	SAH	Rt P ₂	Medium/saccular	No	SAC complete/5 coils	None/none	5
9	64, F	SAH	Rt P ₂	Medium/saccular	Yes	PAO/7 coils	Paralysis & hemianopsia/thalamus & rt occipital lobe (major)	4
10	77, F	SAH	Rt P ₂	Medium/saccular	Yes	PAO/6 coils	Paralysis & hemianopsia/thalamus & rt occipital lobe (major)	3
11	49, F	SAH	Lt P ₂	Medium/fusiform	Yes	PAO/5 coils	Paralysis & hemianopsia/thalamus & rt occipital lobe (major)	3

Pt = patient; SAC = selective aneurysm coiling.

* There were no cases of recanalization in this study.

† The cases of Patients 1–11 are presented in Figs. 1–11, respectively.

FIG. 1. Patient 1. **A:** CT scan shows intraventricular hemorrhage in the right side. **B:** Cerebral angiogram confirms the irregular saccular aneurysm involving the P₂ segment of the right fetal-type PCA. **C:** The patient was treated by coil occlusion of the aneurysm, together with the parent PCA. Intraoperative angiography reveals total obliteration of the aneurysm and the parent artery. **D:** CT scan 2 days later reveals right occipital lobe and thalamus infarctions.

(Patients 1, 9, 10, and 11) were then transferred to the neurointensive care unit, and subcutaneous low-molecular-weight heparin was administered. The other patients (n = 7) received aspirin (100 mg every day) for the prevention of thrombosis from the first day after surgery for 1 year.

Follow-Up

Follow-up was conducted by telephone and in outpatient visits. Angiographic follow-up by DSA or MR angiography (MRA) was subsequently scheduled for 3 months and 1 year after discharge.

Results

Clinical and Angiographic Results

Two aneurysms (in Patients 3 and 8) that were selectively coiled totally or subtotally showed no sign of aneurysm recanalization during follow-up, and the parent arteries were patent. One of these patients, who presented with paralysis on admission, did not experience normalization of motor function. Of the other 9 patients who underwent parent artery occlusion (PAO), 4 had a complication resulting in different levels of permanent paralysis and hemianopsia (Patients 1 and 9–11). There were no severe neurological complications for the rest of the patients

(Patients 2 and 4–7), even though they had minor occipital lobe infarction after PAO. All the patients were followed up for 12–33 months. Except for Patients 1, 6, and 9–11, the other patients had a Glasgow Outcome Scale (GOS) score of 5 at the 1-year follow-up. In all cases, MRA or DSA, obtained at the time of follow-up, revealed that the occlusion of the parent artery remained stable and that there was no recanalization of any of the aneurysms.

Illustrative Cases

Patient 1

A 57-year-old man presented to our department with a chief complaint of acute headache for 12 days. CT scanning revealed IVH in the right side, and CT angiography (CTA) revealed an aneurysm at the right PCA and the absence of the ipsilateral P₁ segment. Cerebral angiography confirmed the irregular saccular aneurysm involving the P₂ segment of the right fetal-type PCA. The patient was treated by coil occlusion of the aneurysm and parent PCA through an ICA-PCoA approach. Intraoperative angiography revealed total obliteration of the aneurysm and parent artery. The patient had paralysis after the operation, and CT scanning 2 days later revealed right occipital lobe and thalamic infarctions. The patient's motor dysfunction

FIG. 2. Patient 2. **A:** Preoperative 3D reconstruction of the CTA image reveals a saccular aneurysm located at the left P₂–P₃ junction. **B and C:** Postoperative 3D reconstructions show that this aneurysm was totally coiled together with its parent artery, a branch of P₃. **D:** A negative sign of major infarction is shown in a postoperative CT examination. Figure is available in color online only.

FIG. 3. Patient 3. **A and B:** Cerebral angiograms confirm the saccular aneurysm involving the P₂ segment of the right fetal-type PCA. The P₁ segment is absent in the vertebral angiogram. **C:** The aneurysm is selectively coiled without occlusion of the parent artery. **D:** MRA study at the 1-year follow-up shows no recanalization of the aneurysm.

had not normalized by either the time of discharge or the 1-year follow-up (Fig. 1).

Patient 3

A 49-year-old man suffered from an acute headache. CTA scanning revealed an intracranial hematoma and a right P₂ segment aneurysm. DSA showed that the aneurysm was saccular and involved the P₂ segment of the right fetal-type PCA. Given our previous experience (Patients 1 and 9–11), which showed that occluding fetal-type PCAs can lead to motor dysfunction, this aneurysm was selectively coiled, and the parent artery was kept patent. The patient recovered well without any complication. He had a GOS score of 5, and MRA revealed no recanalization of the aneurysm at the 1-year follow-up (Fig. 3).

Patient 4

A 57-year-old man presented to our department complaining of an unbearable headache and vomiting. CT scanning revealed a pontine hemorrhage on the left side. The patient underwent emergency cerebral angiography, which further confirmed a large fusiform aneurysm originating from the P₂ segment of the left PCA. The aneurysm and parent PCA were coiled together without any complication either intraoperatively or at the 1-year follow-up (Fig. 4).

FIG. 4. Patient 4. **A:** CT scan shows a pontine hemorrhage. **B:** Cerebral angiogram shows a fusiform aneurysm involving the P₂ segment of the left adult-type PCA. **C:** The aneurysm and parent artery are coiled simultaneously. **D:** Postoperative CT scan shows no infarction of the PCA territory.

Discussion

Anatomical and Clinical Features

The PCA is classically divided into 4 segments.²³ Embryologically, the P₁ segment, which belongs to the basal artery system, originates from the top of the basal artery and courses up to the end of PCoA. An adult-type PCA has multiple thalamoperforating arteries as its most important branches, which are short of collateral circulation. The long circumflex artery derives from the P₁ segment, forming a collateral circulation with the short circumflex artery, which is the branch of the P₂ segment, at the rostral territory of the thalamus.³ The P₂ segment represents the first part of the true PCA system. In addition to the short circumflex artery, it has other branches such as central branches to the brainstem, ventricular branches, and inferior temporal branches,²³ all of which have well-formed anastomoses. For example, the brainstem branches meet the thalamoperforating branches of the P₁ segment near the middle of the thalamus and the premammillary branch of the PCoA anterior in the lateral nucleus. The ventricular branches have anastomoses to branches of the anterior choroidal arteries and lateral posterior choroidal arteries, and the end of the anterior artery and middle artery form multiple anastomoses at the occipital lobe with the P₄ segment. In an adult-type PCA, the P₂ and distal segments are supplied by the basal artery. Therefore, vertebral angiography can show the course of

FIG. 5. Patient 5. **A:** The patient was admitted to our hospital for the primary onset of IVH, discovered by a CT scan. **B:** DSA study shows a saccular aneurysm at the left P_2 segment. **C:** Postoperative DSA image confirms that the aneurysm and parent artery (P_2) were totally coiled with Guglielmi detachable coils and Onyx18. **D:** There was no major brain infarction detected by CT scanning at the time of reexamination.

the PCA, whereas ICA angiography fails to show development. However, in the so-called fetal-type PCA, which contributes one third of the circle of Willis,¹ the PCA remains in its embryological state, arising directly from the ICA. In this case, the P_1 segment is either absent or smaller than that of the PCoA; according to this anatomical feature, fetal-type PCAs are usually divided into 2 categories, full fetal-type PCAs and partial fetal-type PCAs, respectively. In contrast to the adult type, fetal-type PCAs completely show their course only in ICA angiography. As previously mentioned, the long circumflex artery, one of the P_1 segment branches, meets with the short circumflex artery, which is the branch of the P_2 segment, at the rostral territory of the thalamus. The malformation or absence of the P_1 segment in fetal-type PCAs reduces collateral circulation, causing altered blood supply in the rostral territory of the thalamus. Thus, we speculate that thalamus infarctions and motor dysfunction are caused by this altered anatomical feature.

According to their location, PCA aneurysms are usually classified as those of the P_1 segment, the P_1 -PCoA junction, the P_2 segment, the P_3 segment, and the P_4 segment. Compared with other intracranial aneurysms, PCA aneurysms are uncommon lesions that account only for

0.7%–2.3% of all intracranial aneurysms.^{5,7,10,16,17,19} Given the low incidence of total PCA aneurysms, P_2 segment and distal PCA aneurysms are even rarer, often reported as part of a limited case series or general reviews of PCA aneurysms. Unlike other aneurysms, P_2 segment and distal aneurysms tend to be larger, serpentine, and dissecting.^{16,17,19} Clinically, those aneurysms are often not detected until rupture, which will cause spontaneous SAH. They are, however, discovered when the large volume causes a mass effect, or in some cases ischemic stroke.¹⁵ Other symptoms often include paralysis, headaches, and visual field loss.¹⁶ The data from our group corroborate those findings.

Treatment Consideration

Before endovascular therapy was widely applied, the treatment of PCA aneurysms was restricted to surgery. The PCA is close to the brainstem and cranial nerves and has many perforating arteries. Thus, direct interventions for those aneurysms, especially for aneurysms that arise between the tip of the basilar artery and the P_2 segment, are more difficult than those for aneurysms of the anterior circle of Willis. To expose the target vessel, parts of the brain, such as the hippocampus and parahippocampus, may be injured (via resection or retraction), and the

FIG. 6. Patient 6. **A:** The patient was admitted to our hospital because of the sudden onset of headache. DSA was performed emergently and shows an aneurysm at the right P_3 segment with simultaneous arteriovenous fistulas at the ipsilateral side. **B:** Superselective catheterization angiogram confirms the detail information of the aneurysm before coiling. **C:** Superselective catheterization angiogram shows the orifices of the fistulas. **D:** Repeat angiography shows that the aneurysm and its parent artery are coiled, with the arteriovenous fistulas occluded by Onyx18.

FIG. 7. Patient 7. **Left:** A 3D reconstruction of DSA image shows a ruptured aneurysm at the left P₂ segment. **Right:** The aneurysm is coiled together with its parent artery by a Guglielmi detachable coil.

nondominant nonfetal PCoA may be sacrificed through a pterional transylvian approach.¹⁹ In addition, using the subtemporal route can cause a temporal lobe retraction injury. Other complications include damage of cranial nerves III and IV.

Surgical approaches and strategies differ, depending on a surgeon's experience and the type of aneurysm (ie, saccular, fusiform, or serpentine). The fact that PCA aneurysms tend to be fusiform and serpentine, with the neck not easily defined, the main goal is to clip the proximal parent artery, excluding the aneurysm from circulation with or without the restoration of distal flow. Furthermore, this technique applies even for saccular aneurysms, because direct clip placement of the aneurismal neck may be difficult. However, excluding aneurysm from normal circulation can be accomplished easily by means of neurointervention without disturbing the surrounding tissue and perforating arteries; according to published literature, this is a safe and effective technique.^{3,4,6,8,9,12–14,18,21,24} With the continuing development of neurointervention, there is a trend to manage PCA aneurysms endovascularly. Despite the shape of the aneurysms, the pathological features of most P₂ segmental and distal aneurysms are considered to be dissecting. These aneurysms, which are selectively coiled, will have a somewhat high rate of recanalization, which will lead to fateful rerupture. Many neurointerventionists prefer to coil the aneurysm together with the parent artery. According to existing reports of endovascular treatment for P₂ segmental and distal aneurysms, most authors make the conclusion that PAO is a safe and effective therapy.^{3,4,6,8,9,12–14,18,21,24}

Pitfall of the PAO

Regardless of the surgical option, it seems that the parent artery cannot be preserved in most cases. Some authors have advocated an end-to-end anastomosis of the parent artery or bypass to avoid insufficient perfusion of the distal area.^{2,22} However, in most intervention case series or reports, occluding the proximal PCA did not result in a poor clinical outcome, neither transiently nor permanently. We reviewed the literature related to P₂ segment and distal aneurysms since 2001 and collected information about these cases^{3,4,6,8,9,12–14,18,21,24} (Table 2). In these reports, there were 98 patients with P₂ and distal segmental aneurysms, and 76 aneurysms were treated by PAO. Two patients with preoperative HH Grade IV or V died, and 1 patient who presented with Hunt and Kosnik Grade IV

FIG. 8. Patient 8. **Left:** A saccular right P₂ aneurysm is shown by DSA performed after the patient was admitted to our hospital. **Right:** The aneurysm was selectively coiled, and its parent artery was kept patent.

died, as reported by van Rooij et al.²¹ and Kashiwazaki et al.,⁹ respectively. No other specific explanations for the deaths (3.95%) were reported. Two other patients had mild motor dysfunction (2.63%); however, they eventually went back to work (GOS score of 4). There were 15 patients who had visual deficits, and 2 of them had it as an initial presentation. Thus, the complication rate of visual deficits was 17.57% (13 of 74). According to the existing data, deaths were related mainly to the onset HH grading but not to the operation itself. Other complications relating to hemianopsia and numbness may occur because of minor infarctions of the occipital lobe. Nevertheless, these deficits do not significantly affect a patient's life. Thus, direct occlusion of the parent vessel is considered to be safe and is recommended as a preferential strategy for managing P₂ segment and distal aneurysms because of the abundant collateral vascular network attributed to the surrounding arteries, as mentioned above.

In contrast to these findings, Lv et al.¹⁴ suggested that this technique may carry a potential risk for patients with fetal-type PCA. However, in their report, fetal-type PCAs were involved in all 3 cases with hemianopia, which was initially presented or caused by parent vessel occlusion.¹⁴ However, in our clinical series, 4 patients with a fetal-type PCA aneurysm treated by PAO presented with paralysis and hemianopia postoperatively. Even though the motor function and visual deficits were attenuated somehow, these patients still had diverse neurological dysfunctions in the long-term follow-up. CT scanning detected thalamic infarction in all 4 patients after intervention, indicating insufficient collateral circulation of the thalamic territory in patients with a fetal-type PCA, as mentioned above. We suggest that fetal-type PCAs should be an independent risk factor of PAO. We assume that complications have not been reported because of the selective bias for good outcomes or the rare incidence of fetal-type PCA aneurysms. The PAO technique should be reevaluated for patients with a fetal-type PCA.

On one hand, there were no deaths, complications, or recanalization of the aneurysms in our study, which proves the previous conclusion that PAO is safe and effective in patients with an adult-type PCA. On the other hand, we report that fetal-type PCAs are the pitfall of PAO for treating

FIG. 9. Patient 9. **A:** Preoperative CT scan shows SAH (at admission). **B and C:** A fetal-type PCA aneurysm is shown by angiography (P_2 segment). **D:** Postcoiling image shows that the aneurysm was totally coiled and delayed development of the parent artery, which was occluded later. **E and F:** Postoperative CT scan shows an enlarged ventricle together with minor thalamic and paraventricular infarctions.

P_2 and distal segmental aneurysms, which is in line with the findings of Lv et al.¹⁴ To our knowledge, we are the first to suggest that fetal-type PCA aneurysms be recognized as an individual category.

Balloon Occlusion Test

The BOT is widely used for evaluating patient tolerance of PAO, but it remains controversial. Although angiography after a temporary BOT can show collateral circulation of the PCA territory, for perforating arteries, BOT had both false-positive and false-negative results.¹¹ Also, there is a technique-related risk that results from the twisting nature of the PCA, which increases the difficulty in delivering the balloon to the target vessel. On the other hand,

although no clinical trials have been conducted, many authors have noted that patients can tolerate direct PCA occlusion. On the basis of our clinical experience, we believe that a BOT is not necessary for adult-type PCAs. However, for patients with a fetal-type PCA, for which there is no other alternative means to analyze their tolerance of PAO, the BOT is still a reliable way to ensure safety. If patients have ischemic symptoms after a BOT, it is better to establish an end-to-end anastomosis of the parent artery or bypass before PAO.

Limitations of the Study

Because our case number is low, there is an inherent limitation to our statistical analysis in further confirming

FIG. 10. Patient 10. **A:** A fetal-type PCA aneurysm is shown by angiography (P_2 segment). **B:** The aneurysm is totally coiled together with its parent artery. **C and D:** Postoperative CT scan shows a major ipsilateral occipital infarction and a minor thalamic infarction.

FIG. 11. Patient 11. **A:** A fetal-type PCA aneurysm is by angiography (P_2 segment). **B:** The aneurysm is totally coiled together with its parent artery. **C and D:** Postoperative CT scans show a major ipsilateral occipital infarction and a minor thalamic infarction.

our conclusion. However, there are no epidemiological P_2 segment and distal aneurysm data so far. The literature regarding the therapy of P_2 segment and distal aneurysms are extremely limited to small case series and case reports. Given the low rate of P_2 segment and distal aneurysms and fetal-type PCA aneurysms, it is not possible for our single center to collect enough cases to draw definitive conclusions. However, the notable connection between ischemic complications, such as motor dysfunction and visual deficits, and PAO that we have discovered in patients with a fetal-type PCA aneurysm should be studied further. Thus, we suggest that it is important to report this phenomenon for further discussion and clinical study.

We speculate that motor dysfunction and visual deficits are related to the insufficient collateral circulation of the fetal-type PCA. However, there is not enough anatomical

information in the literature for explanations so far, which is another limitation of our study. We suggest that more anatomical studies of fetal-type PCAs be carried out.

Conclusions

For adult-type P_2 segment and distal PCA aneurysms, endovascular occlusion of the aneurysm and its parent artery is widely considered a safe and effective strategy. Nevertheless, our clinical experience suggests that this method is of high risk for patients with a fetal-type PCA aneurysm, which, because of the insufficient collateral circulation of the thalamus, can lead to a poor clinical outcome. A BOT may help evaluate a patient's tolerance of PAO. However, for those with a fetal-type PCA aneurysm, it is advisable to keep the parent artery patent by either se-

TABLE 2. Summary of the patients with P_2 and distal aneurysms in a recent literature review*

Authors & Year	No. of P_2 & Distal Cases	Age Range (yrs)	PAO (no. of cases)	Preop HH Grade of >2 in PAO Cases (no. of cases)	FU (mos)	Permanent Motor Deficit of PAO (no. of cases [severity])	Visual Deficit of PAO (no. of cases)
Ciceri et al., 2001	7	12–58	6	0	NA	0	1
Hallacq et al., 2002	10	18–70	9	0	12–72	0	1
Hoya et al., 2006	4	23–62	2	I	NA	1†	1†
van Rooij et al., 2006	6	27–64	5	II	6–12	2 deaths‡	1‡
Cotroneo et al., 2007	4	19–54	4	0	12	0	2
Zhao et al., 2008	8	12–60	3	0	NA	0	0
Kashiwazaki et al., 2011	14	49–78	9	V	NA	1 death§	2
Liu et al., 2011	12	16–73	12	0	2–25	1 (mild, GOS Score 4)	2 (mild)
Taqi et al., 2011	7	5–62	4	NA	11–43	0	0
Luo et al., 2012	10	18–66	6	0	6–12	1 (mild, GOS Score 4)	2
Lv et al., 2012	16	4–58	16	NA	6–42	0	3¶
Total	98	4–78	76			6 (3 deaths)	15 (13 new)

FU = follow-up; NA = not applicable.

* There were no cases of recanalization in these studies.

† This patient had an adult-type PCA. Although the authors reported it as a P_2 segment aneurysm, according to their figure, the aneurysm was located at the P_1 – P_2 junction but not at the P_2 segment.

‡ In their cases, 2 patients died with preoperational HH Grades IV and V. One patient had hemianopsia, which was the same condition with which she presented.

§ The neurological status of each patient was recorded at admission by using the Hunt and Kosnik grading system. One patient who presented with Hunt and Kosnik Grade IV died.

¶ Of the 3 patients who had a visual deficit, 1 had hemianopia at the initial presentation. All of them had a fetal-type PCA. Their visual deficits did not affect their work.

lective coiling or an end-to-end bypass of the PCA. Given this information, more anatomical information on fetal-type PCAs is needed.

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