# SURGICAL MANAGEMENT OF FUSIFORM ANEURYSMS OF THE PERIPHERAL POSTEROINFERIOR CEREBELLAR ARTERY

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**OBJECTIVE:** To describe the management and outcomes of seven patients with fusiform aneurysms of the peripheral posteroinferior cerebellar artery (PICA).

**METHODS:** Medical records and neuroimaging studies of seven patients who underwent surgical treatment of fusiform aneurysms of the peripheral PICA were reviewed. Average follow-up time was 1.5 years, and no patient was lost to follow-up.

**RESULTS:** All patients presented with acute subarachnoid hemorrhage, and most had acute hydrocephalus. All underwent surgery, which entailed distal revascularization in six of the seven patients. Revascularization techniques included occipital artery–PICA bypass, side-to-side PICA-PICA anastomosis, and aneurysm excision with direct end-to-end PICA reanastomosis. Outcome was good in six patients and fair in one.

**CONCLUSION:** Fusiform, peripheral PICA aneurysms are rare lesions. Distal revascularization was used in most cases because of the uncertain adequacy of collateral supply. Careful, individualized management allows for a good outcome in the majority of cases.

**KEY WORDS:** Aneurysm, Bypass, Fusiform, Posteroinferior cerebellar artery

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Aneurysms arising from the posteroinferior cerebellar artery (PICA) distal to its origin from the vertebral artery are rare, accounting for less than 1% of all intracranial aneurysms (7, 14, 17, 18). Most of these peripheral PICA aneurysms are saccular lesions that arise at branching points or at curves in the parent vessel and point in the direction that flow would have otherwise taken (7). We describe an unusual series of patients with fusiform, peripheral PICA aneurysms. Management strategies for these complex and uncommon lesions are described, and the pertinent literature is reviewed.

## PATIENTS AND METHODS

We retrospectively reviewed the records of seven patients with fusiform, peripheral PICA aneurysms treated at our institution between 1996 and 2001. Follow-up ranged from 9 months to 3 years (average, 1.5 yr). Hospital records, neuroimaging studies, operative reports, and follow-up clinic notes were available in all cases. No patient was lost to follow-up review.

PICA aneurysms were defined as peripheral if there was a clear segment of normal PICA proximal to the aneurysm. Aneurysms were considered to be fusiform when they had no discernible neck and when the parent artery entered and then emerged from the aneurysm at separate sites. One patient had an additional, incidental superior hypophyseal aneurysm; none had an associated arteriovenous malformation.

All patients underwent surgical repair of their aneurysms within 24 hours of presentation. The aneurysm was missed at initial angiography at an outside facility in one patient. Patients underwent surgery via a far-lateral suboccipital approach with partial condylar resection. In all patients, the occipital artery was identified, dissected over a long course, and preserved. The ipsilateral vertebral artery was identified extradurally at the C1 level and then traced intradurally to the PICA origin. With proximal control achieved, the aneurysm was exposed to assess the possibility of clip reconstruction.

In the present series, no aneurysm was deemed suitable for direct clip reconstruction, and trapping with distal revascularization

was the treatment of choice. The specific method of revascularization used in each patient depended on the regional anatomy and location of the aneurysm. Revascularization techniques included direct end-to-end repair, side-to-side PICA-PICA bypass, or occipital artery–PICA bypass. Mild hypothermia (34°C) and barbiturate neuroprotection were used in all patients.

## RESULTS

Patient information, angiographic findings, and surgical results are detailed in *Table 1*. There were six men and one woman in this series. All patients presented with acute subarachnoid hemorrhage. All had some component of intraventricular hemorrhage, and this was the predominant finding in five patients. Six patients had varying degrees of hydrocephalus, presumably related to the intraventricular blood. The aneurysms were small in five of the seven patients, but there was one large aneurysm and one giant lesion (*Fig. 1*).

In all cases, the proximal location of the aneurysms and uncertainty regarding the adequacy of collateral supply suggested that some form of distal revascularization was appropriate. Occipital artery–PICA bypass was used earlier in our experience in three patients (*Figs. 2* and *3*). PICA-PICA side-to-side anastomosis (two patients) and direct end-to-end PICA repair (one patient) were considered preferable techniques in our more recent experience because of the possibility of watertight dural closure. In one patient, the aneurysm ruptured during the final stages of dissection. Placement of a clip on the PICA just proximal to the aneurysm failed to slow the bleeding, implying robust collateral supply. This aneurysm was trapped between clips without revascularization. The patient did well, and control angiography revealed excellent collateral filling of the PICA from a large, ipsilateral anteroinferior cerebellar artery.

Patient outcomes are listed in *Table 1*. Overall, six patients had good outcomes and were able to return to their premorbid level of functioning. One patient with a giant aneurysm had a fair outcome. This patient experienced postoperative vasospasm and developed a pseudomeningocele and wound infection. He was left with long-standing vertigo and bilateral sixth nerve palsies. Delayed magnetic resonance imaging scans revealed a small area of ischemic change in the midpons, presumably related to the vasospasm.

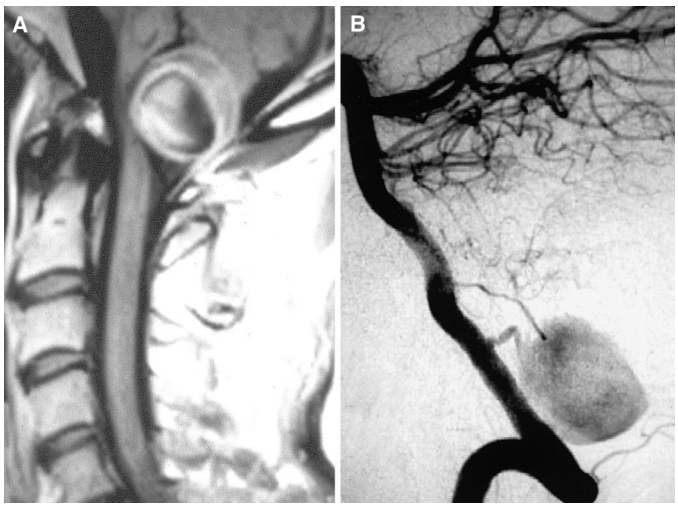


**FIGURE 1.** *Patient 3.* A, *sagittal T1-weighted magnetic resonance imaging scan revealing heterogeneous signal within a giant PICA aneurysm.* B, *lateral vertebral arteriogram revealing the giant aneurysm that was treated by occipital artery–PICA bypass, then trapping and excision of the aneurysm.*

All patients underwent control angiography after surgery. Aneurysm exclusion was confirmed in all patients. One occipital artery–PICA bypass was found to be occluded, but the patient was asymptomatic, and good anteroinferior cerebellar artery collateral supply was now irrigating the distal PICA territory. In two patients, the aneurysm itself was excised and submitted for pathological examination. In these instances, histopathology revealed the typical findings of an intracranial aneurysm with the vessel walls exhibiting mild atherosclerotic

**TABLE 1. Patient characteristics and surgical results[a]**

| Patient no. | Age (yr)/sex | Presentation | Treatment | Outcome |
|---|---|---|---|---|
| 1 | 40/M | SAH, IVH | OA-PICA, trap | Good |
| 2 | 39/M | SAH, IVH | Trap, ++ collaterals | Good |
| 3 | 55/M | SAH | OA-PICA, trap, excision | Fair |
| 4 | 49/M | SAH, IVH | OA-PICA, trap | Good |
| 5 | 42/M | SAH, IVH | PICA-PICA, trap | Good |
| 6 | 32/M | SAH, IVH | PICA-PICA, trap | Good |
| 7 | 62/F | SAH, IVH | End-end, excise | Good |

[a] SAH, subarachnoid hemorrhage; IVH, intraventricular hemorrhage; OA, occipital artery; PICA, posteroinferior cerebellar artery; ++, robust.

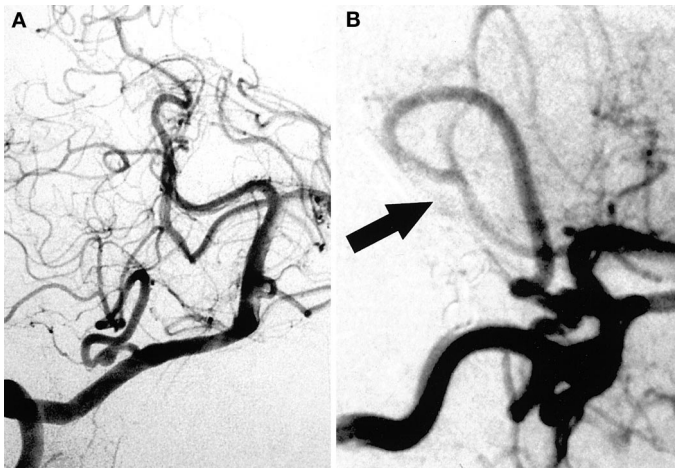


**FIGURE 2.** *Patient 4.* A, *anteroposterior vertebral arteriogram revealing a small fusiform aneurysm of the PICA that had resulted in significant intraventricular and subarachnoid hemorrhage. The lesion was treated by occipital artery–PICA bypass, then trapping of the involved arterial segment.* B, *postoperative external carotid arteriogram revealing the anastomosis* (arrow) *and filling of the PICA territory by the occipital artery.*

change, fragmentation of the internal elastic lamina, and loss of the tunica media.

## DISCUSSION

### Historical Perspective

The earliest description of an intracranial aneurysm arising at the origin of the PICA has been credited to Cruveilhier in 1829 (7). Wichern reported a peripheral PICA aneurysm in 1912, and Olivecrona may have surgically treated this entity as early as 1932 (2, 6). Rizzoli and Hayes (15) treated a peripheral PICA aneurysm with trapping in 1953, and DeSaussure et al. (3), in 1958, reported two PICA aneurysms that had been defined by preoperative angiography and then trapped surgically.

For many years, the majority of peripheral PICA aneurysms were managed nonoperatively (2, 6, 13). In 1986, Beyerl and Heros (2) reviewed 62 reported cases of surgically treated peripheral PICA aneurysms, and Drake (5), in his book, describes a total of 21 peripheral PICA aneurysms and two peripheral PICA dissections. Of the 21 aneurysms, 13 occurred at branch points, eight were found at the apex of a curve in the parent artery, and none were described as "fusiform." As reported by both Hudgins et al. (7) and Beyerl and Heros (2), most of these peripheral PICA aneurysms seem to be saccular in nature and are therefore amenable to standard clipping techniques. Truly fusiform aneurysms involving the peripheral PICA seem to be extremely rare lesions. It is possible that some of the patients we describe in fact represent focal dissections of the PICA, although in two patients, the aneurysm was excised and submitted for pathological examination, which confirmed the typical histology of an intracranial aneurysm rather than dissection (12).

### Anatomy

The PICA has been divided into five segments (7, 10). The anterior medullary, lateral medullary, and tonsillomedullary segments may give rise to brainstem perforators; the telovelotonsillar and cortical segments do not. It has therefore been suggested that aneurysms arising from or distal to the telovelotonsillar segment may be treated by trapping without revascularization (7). All of the lesions encountered in the present series occurred proximal to the telovelotonsillar segment, suggesting the need for consideration of distal revascularization.

### Surgical Considerations

The importance of performing a complete four-vessel angiogram in this setting has been emphasized previously (2, 11). The typical three-vessel study, in which a single vertebral artery is injected and reflux down the contralateral vertebral is used to reveal the PICA origin, will undoubtedly fail to reveal this lesion in some patients. In our series, one aneurysm was initially missed on such a limited study performed at an outside institution. Therefore, if the pattern of hemorrhage suggests a PICA aneurysm—and in particular if there is associated intraventricular hemorrhage, which may imply a more peripheral aneurysm location—both vertebral arteries should be studied completely.

It should be noted that most peripheral PICA aneurysms, like most intracranial aneurysms, are saccular in nature and are amenable to standard clip reconstruction. Because it can be very difficult to be certain that the aneurysm is truly fusiform without direct operative inspection, we recommend exposing the aneurysm to assess the feasibility of clip reconstruction. In our patients, clipping was deemed either impossible or inadvisable because aneurysmal vessel would have been left behind, with the potential for delayed reexpansion and bleeding. It is possible that some of the aneurysms in our series could have been treated with a clip graft or some combination of encircling clips with wrap reinforcement. Nevertheless, as mentioned, this strategy would not have excluded the aneurysmal and often very dysplastic arterial segment from the intracranial circulation.

Because of the uncertain potential for clip reconstruction of these lesions, the surgeon operating on a fusiform aneurysm of the peripheral PICA must be prepared to perform some form of distal revascularization unless the aneurysm is located on or distal to the telovelotonsillar segment of the PICA. We recommend meticulous preservation and preparation of the occipital artery during the opening in this setting. Dissection of the occipital artery may be relatively tedious, and if an urgent need arises for revascularization (i.e., if the aneurysm should rupture during dissection, necessitating temporary occlusion of the PICA), there may not be sufficient time to dissect and then anastomose the occipital artery if it has not already been prepared. In our more recent cases, when feasible, we have used an in situ technique consisting of end-to-end repair or side-to-side PICA-PICA anastomosis (1, 4, 8, 9). These options allow for watertight dural closure. Nevertheless, the complex local anatomy may make these procedures

difficult or impossible, and we still attempt to prepare the occipital artery in all cases.

That one patient tolerated occlusion of the occipital artery–PICA bypass without symptoms emphasizes the complex and variable anatomy of the anteroinferior cerebellar artery–PICA complex (16). Clearly, some patients will have sufficiently adequate collateral supply to tolerate PICA sacrifice. In general, however, it is not possible to assess in advance the adequacy of such collateral flow. The potentially severe consequences of ischemia to the brainstem perforators that arise from the more proximal PICA segments warrant an attempt at revascularization whenever possible (2, 4, 7–9, 11, 16).

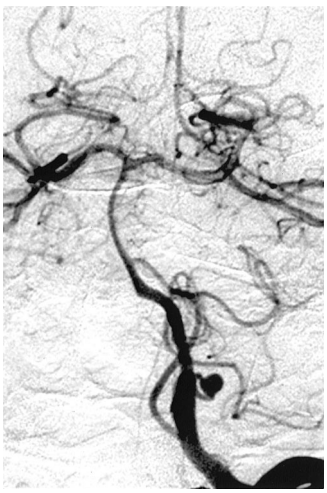

**FIGURE 3.** *Patient 6. Anteroposterior vertebral arteriogram revealing a small aneurysm involving the PICA in a patient with subarachnoid and intraventricular hemorrhage. This lesion was treated by PICA-PICA bypass, then trapping of the aneurysm.*

## CONCLUSIONS

Peripheral PICA aneurysms are rare; those that are fusiform rather than saccular are particularly uncommon. We describe an unusual series of patients with this entity. All presented with hemorrhage, and all were managed surgically. We reiterate the need for a complete four-vessel angiogram to identify these easily missed lesions. The importance of preparing for distal revascularization is emphasized as well. The variable anatomy of these aneurysms, which may occur on any segment of the PICA, demands some degree of flexibility on the part of the surgeon regarding approach and strategy. Revascularization options, including occipital artery–PICA bypass, PICA-PICA bypass, and end-to-end anastomosis, have all been used with success in our experience. With thoughtful preoperative planning, a favorable outcome can be achieved in the majority of patients.

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## COMMENTS

Nussbaum et al. report on a series of fusiform aneurysms of the posteroinferior cerebellar artery (PICA). These aneurysms were not treatable with vessel reconstruction; therefore, the aneurysms were trapped. The authors felt compelled to proceed with distal revascularization. Their outcomes seem to be excellent, but there is very little information in this series that warrants the extensive use of distal revascularization for PICA aneurysms. It is usually the most proximal segment of the PICA that contains the critical perforators to the brainstem. When the PICA is sacrificed distal to this most proximal segment, anastomosis and revascularization of the distal territory of the PICA do little to protect the brainstem. The cerebellar stroke that sometimes occurs with distal PICA sacrifice is usually clinically irrelevant; often, such a stroke does not occur, as a consequence of the rich cortical anastomosis of the various cerebellar arteries. Among the cases that the authors report, one patient did not receive a bypass and another had a failed bypass. Neither of these patients incurred brainstem ischemia. This finding further supports the hypothesis that distal revascularization does little to protect brainstem perforators. In my experience with PICA aneurysms, any type of brainstem injury has clearly been related to direct perforator injury or to the sacrifice of a segment of the PICA with direct perforators. I believe that PICA revascularization should be considered when the vertebral segment containing the origin of the PICA is sacrificed or if the most proximal portion of the PICA needs to be sacrificed. Once the sacrifice is

distal to the proximal portion of the PICA containing the critical brainstem perforators, it seems unlikely that distal revascularization would do much to protect the brainstem.

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The authors report seven patients with an unusual cerebrovascular entity: distal and fusiform aneurysms of the PICA. A number of the key points put forward should be emphasized:

*1. Collateral potential*. Infarctions involving the lateral aspect of the medullar area are usually disabling. The PICA gives rise to numerous medullary perforators in its initial passage through the anterior and lateral medullary subarachnoid space. It is commonly believed, and my experience bears this out, that sacrifice of the PICA without vascularization proximal to the telovelotonsillar segment is hazardous.

*2. Surgical exploration is mandatory*. Some of these lesions, despite their angiographic appearance, are in fact broad-based saccular aneurysms or reconstructible fusiform aneurysms. I had a recent case that looked purely fusiform but, on microsurgical inspection, had very healthy tissue along part of the circumference. Thus, there was healthy tissue to allow reconstruction of a durable conduit with a right-angled fenestrated clip.

*3. Preservation of the occipital artery*. In general, the occipital artery is a relatively suboptimal donor because of its early branching and rapid loss of diameter in light of the length required to perform this deep anastomosis. However, even if one plans an internal revascularization procedure, one never knows for sure whether such a plan will be feasible. I have been chagrined to find an acceptable contralateral PICA caudal loop for a planned side-to-side bypass and also have found the proximal PICA segment as well as the distal segment to be tethered by medullary perforating arteries, which precluded adequate mobilization for an end-to-end reconstruction after trapping.

In some cases, it is possible to consider a PICA trial balloon occlusion. Ischemic tolerance in this situation will be very helpful in the decision analysis, but it is important to keep in mind that the aneurysm may be a result of proximal dissection.

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Nussbaum et al. present a series of seven patients with fusiform aneurysms of the peripheral PICA treated with trapping and distal revascularization. During this experience, they developed a preference for the PICA-to-PICA bypass over the occipital artery-to-PICA bypass. This in situ side-to-side anastomosis is easily performed between the cerebellar tonsils where the PICAs course parallel and in close proximity to each other, sparing the neurosurgeon the tedious task of dissecting the occipital artery and increasing the likelihood of patency (one of the occipital artery-to-PICA bypasses occluded). This anastomosis requires suturing the posterior walls together from inside the lumen of the arteries with a running stitch, which is slightly more difficult than the usual bypass. Like the authors, I favor this technique over the others and have performed four such bypasses for PICA aneurysms, because it creates multiple options for safely occluding the aneurysm. It would be more satisfying if one could clearly demonstrate the need for the bypass. This territory is well collateralized from the anteroinferior cerebellar artery laterally and the superior cerebellar artery superiorly. Two patients in the series had good outcomes without distal revascularization (one with an occluded bypass and one with brisk back-bleeding from the aneurysm deemed not to need the bypass), attesting to this extensive collateral network. Unfortunately, no provocative occlusion test exists for the PICA territory. I agree with the authors that in the absence of such a test, distal revascularization is justified; it is better to perform an unnecessary bypass than not to perform a necessary one.

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