AJNR

Vertebrobasilar junction aneurysms associated with fenestration: treatment with Guglielmi detachable coils.

V B Graves, C M Strother, B Weir and T A Duff

AJNR Am J Neuroradiol 1996, 17 (1) 35-40
http://www.ajnr.org/content/17/1/35

Vertebrobasilar Junction Aneurysms Associated with Fenestration: Treatment with Guglielmi Detachable Coils

Virgil B. Graves, Charles M. Strother, Bryce Weir, and Thomas A. Duff

Summary: Three patients with vertebrobasilar junction aneurysms and associated fenestration were treated with Guglielmi detachable coils. The structure and hemodynamics of fenestrations may account for their frequent association with aneurysms. The complex hemodynamics of these aneurysms requires evaluation of both vertebral arteries. One treatment complication occurred but resulted in no deficit. All patients have returned to normal activity and remain healthy at 14 to 46 months.

Index terms: Aneurysm, embolization; Arteries, vertebral; Interventional materials, coils

Saccular aneurysms of the vertebrobasilar junction are uncommon but when present often are associated with a fenestration of the basilar artery. The complex anatomy of this region includes multiple small perforating arteries to the brain stem and multiple lower cranial nerves. This complex anatomy and the difficulty of adequate surgical exposure make surgical clipping a formidable task. During the past 4 years, three patients with vertebrobasilar junction aneurysms and associated fenestration have been referred for endovascular treatment. These patients were treated with Guglielmi detachable coils (Target Therapeutics, Fremont, Calif) as part of a multicenter clinical trial approved by the US Food and Drug Administration and the investigational review board of the University of Wisconsin. The technique and clinical use of the Guglielmi detachable coils have been previously described (1–3). This report emphasizes that an understanding of the embryologic development of basilar artery fenestration and its structure and hemodynamics are necessary for accurate diagnosis and safe treatment of these aneurysms.

Case Reports

Three patients with vertebrobasilar junction aneurysms and associated basilar artery fenestration were referred for treatment with Guglielmi detachable coils (one woman, two men, ages 48 to 72 years). One presented with a ruptured aneurysm, and the other two presented with unruptured aneurysms but with symptoms related to mass effect. The average imaging follow-up was 10 months, with a range of 6 to 14 months. The average clinical follow-up was 30 months, with a range of 16 to 46 months.

Case 1

A 72-year-old woman awoke with a severe headache and a left third and sixth cranial nerve palsy. Computed tomography showed subarachnoid hemorrhage. Angiography demonstrated a 9 × 18-mm vertebrobasilar junction aneurysm. Angiography was significant in that initially the aneurysm and fenestration opacified only with injection of the right vertebral artery (Fig 1A). There was no filling of the aneurysm or evidence of a fenestration from injection of the left vertebral artery (Fig 1B). Because of marked tortuosity of the aorta and neck vessels, access to the aneurysm could be obtained only via a right brachial approach. Four coils were placed in the aneurysm via the right vertebral artery. This resulted in partial occlusion (Fig 1C). The residual portion of the aneurysm could not be entered via the right vertebral artery, and only diagnostic angiography could be done via the left vertebral artery from the right brachial approach. The aneurysm could not be catheterized from this approach. The patient refused additional treatment. On follow-up magnetic resonance angiography at 6 months, the aneurysm was unchanged with a persistent residual. The third and sixth nerve palsy had resolved. The patient remains asymptomatic at clinical follow-up of 30 months.

Case 2

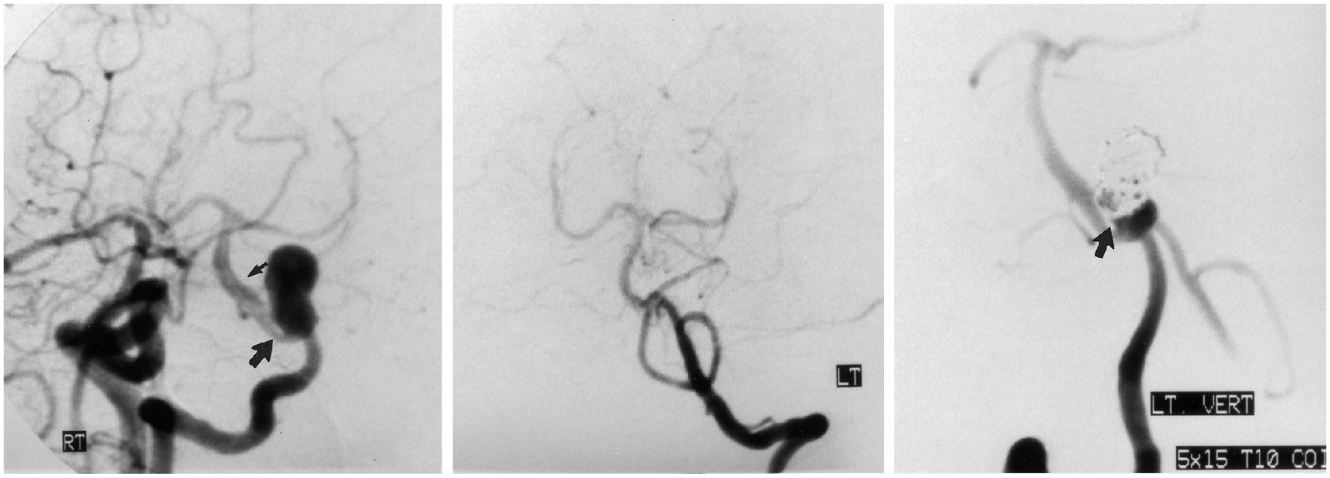
A 63-year-old man presented with progressive headache, dysphagia, and left sixth cranial nerve palsy. An-

Received December 22, 1994; accepted after revision March 13, 1995.

From the Departments of Radiology and Neurosurgery, University of Wisconsin, Madison (V.B.G., C.M.S., T.A.D.); the Section of Neurosurgery, University of Chicago (Ill) (B.W.); and Target Therapeutics, Fremont, Calif (C.M.S.)

Address reprint requests to Virgil B. Graves, Department of Radiology, E3/311, Clinical Science Center, 600 Highland Ave, Madison, WI 53792-3252.

AJNR 17:35–40, Jan 1996 0195-6108/96/1701–0035

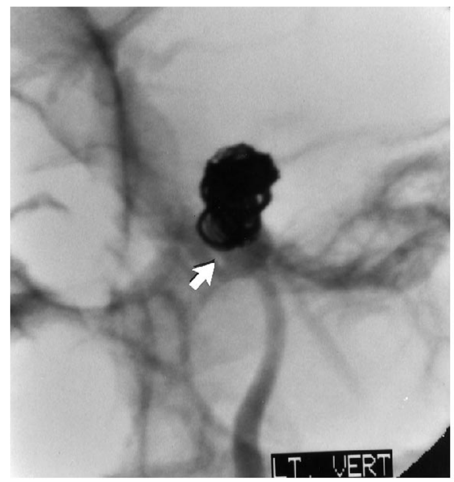


A B C

Fig 1. Case 1. *A,* Right innominate angiogram shows filling of aneurysm and fenestration (*arrows*).

B, Left vertebral angiogram shows no filling of aneurysm or fenestration.

C and *D,* Digital subtracted and unsubtracted left vertebral angiogram after initial Guglielmi detachable coils treatment with partial occlusion of the aneurysm shows filling of the residual aneurysm and demonstrates the fenestration (*arrows*).

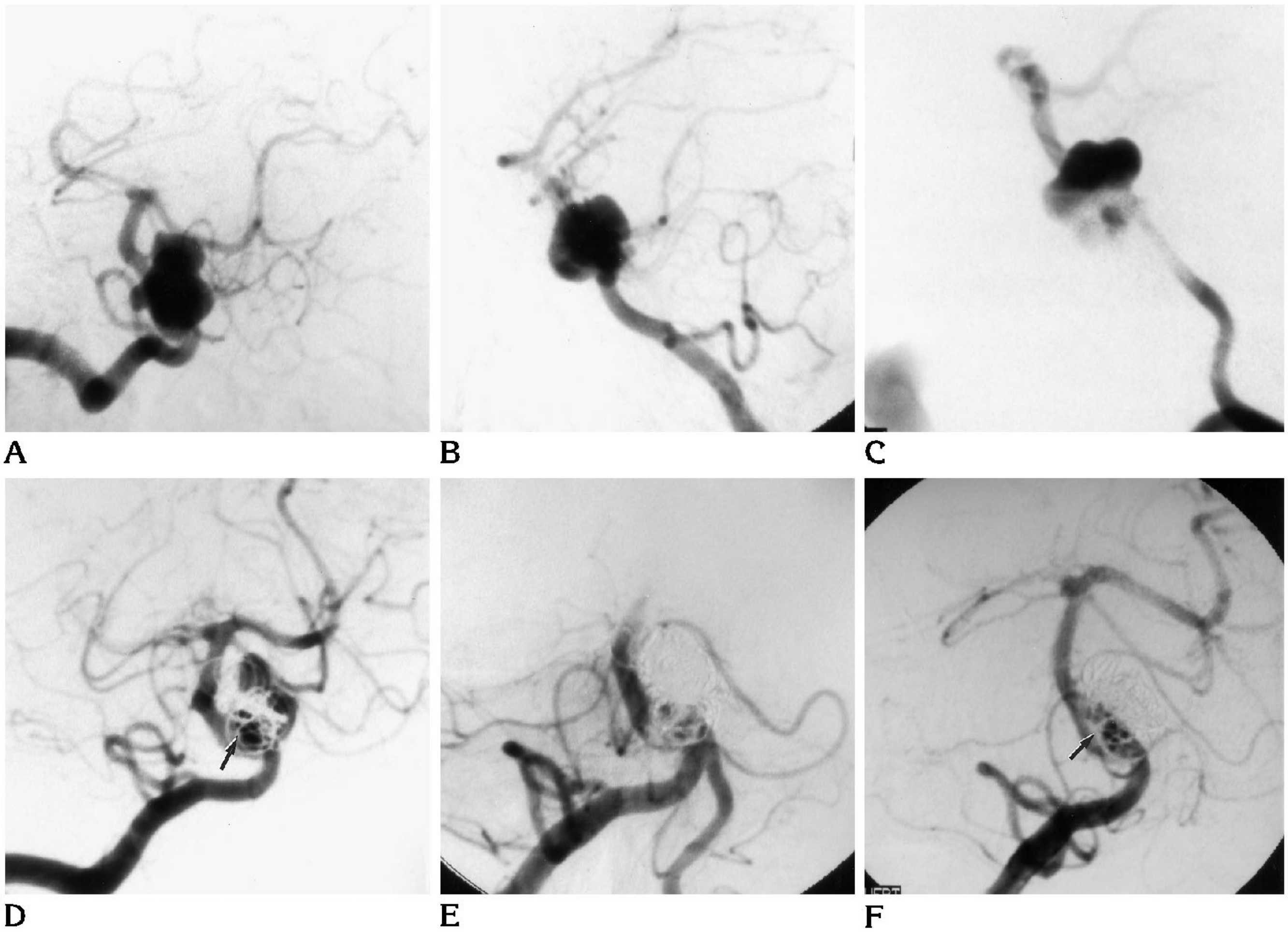


D

giography demonstrated a 12 × 20-mm vertebrobasilar junction aneurysm. The associated fenestration was not apparent on initial angiogram (Fig 2A). The fenestration became clearly apparent only after occlusion of the aneurysm. The complex angiographic compartments within the aneurysm filled distinctly better via injection of one or the other vertebral arteries (Fig 2B, C). The aneurysm was occluded with eight Guglielmi detachable coils placed in three staged procedures. At the completion of the second stage, there was residual aneurysm present, and the fenestration now could be identified (Fig 2D). During completion of the third stage of treatment, the patient became unresponsive, and angiography demonstrated thrombus in one loop of the fenestration as well as in the distal basilar artery (Fig 2E). This was treated with local intraarterial infusion of 100 000 U of urokinase. The thrombus resolved, the patient recovered, and there was no permanent deficit. Angiography at 1 month showed gross complete occlusion of the aneurysm and a patent basilar artery without evidence of thrombus (Fig 2F, G). Magnetic resonance angiography at 10 months showed no flow within the aneurysm, and the patient is doing well on clinical follow-up at 46 months.

Case 3

A 48-year-old man presented with persistent, progressive headache. Angiography demonstrated a 9 × 15-mm vertebrobasilar junction aneurysm. The fenestration and aneurysm were well seen on both the initial left and right vertebral angiograms (Fig 3A). Different angiographic compartments of the aneurysm were better opacified by injection of one or the other vertebral arteries. The aneurysm was occluded with 13 coils in two staged procedures. Initially 9 coils were placed via the left vertebral artery (Fig 3B). The remaining residual aneurysm was better seen angiographically after injection of the right vertebral artery (Fig 3C). In addition, this residual aneurysm compartment could be entered only via the right vertebral artery. Four additional coils were placed through this approach during a second stage procedure (Fig 3D). Follow-up left and right vertebral artery angiograms at 14 months after place-



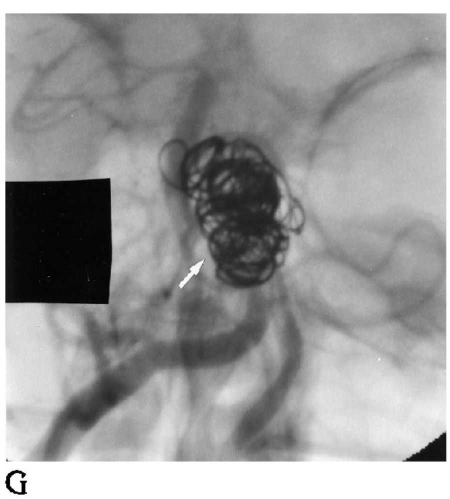


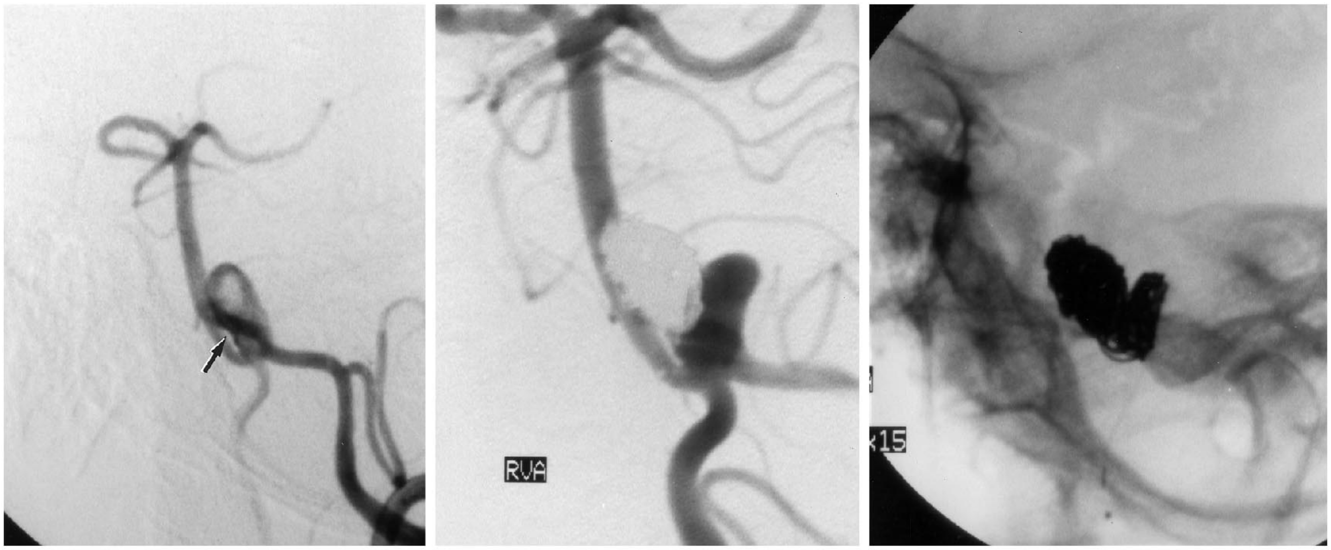
Fig 2. Case 2. *A,* Right vertebral angiogram demonstrates aneurysm but no fenestration.

B and *C,* Lateral views of right vertebral and left vertebral angiograms demonstrate differential opacification within the aneurysm, depending on which vertebral artery is injected.

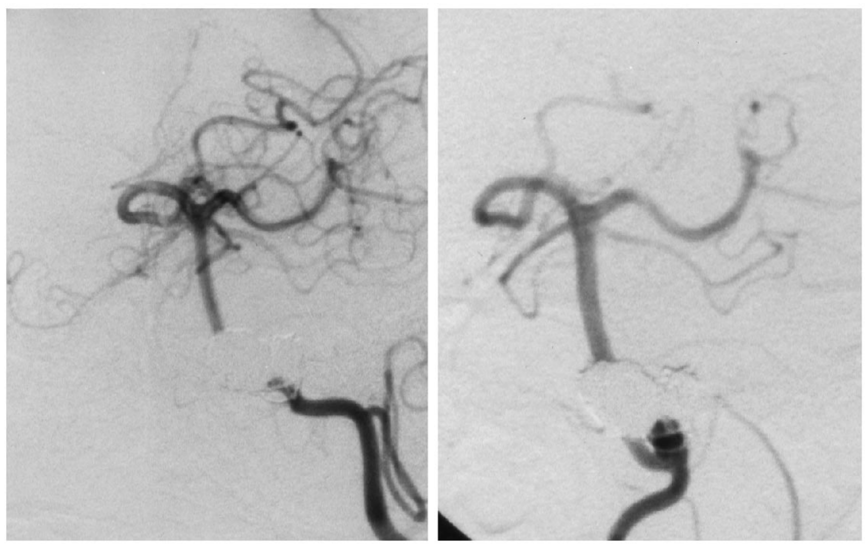
D, Right vertebral angiogram at the end of the second stage shows residual aneurysm and fenestration (*arrow*).

E, Right vertebral angiogram at completion of third stage shows gross complete occlusion of the aneurysm and thrombus in the limb of the fenestration and basilar tip.

F and *G,* Digital subtracted and unsubtracted right vertebral angiogram 1 month after the third stage of Guglielmi detachable coils and urokinase infusion shows persistent gross complete occlusion of the aneurysm and no evidence of thrombus and demonstrates the fenestration (*arrows*).



A B C



D E

Fig 3. Case 3. *A,* Left vertebral angiogram demonstrates aneurysm and fenestration (*arrow*).

B, Oblique right vertebral angiogram demonstrates initial Guglielmi detachable coils and residual aneurysm.

C, Oblique view during second stage of Guglielmi detachable coil placement demonstrates placement of Guglielmi detachable coils in residual aneurysm from right vertebral approach.

D and *E,* Left vertebral and right vertebral angiograms demonstrate persistent gross complete occlusion 14 months after treatment. Right vertebral angiogram shows persistent dilated limb of fenestration. Residual aneurysm cannot be completely excluded.

ment of Guglielmi detachable coils showed persistent gross complete occlusion of the aneurysm (Fig 3E, F). The patient became asymptomatic and is well on clinical follow-up at 16 months.

Discussion

The typical origin of the vertebrobasilar junction aneurysm at the proximal portion of the fenestration, the complex geometry of the fenestration, the proximity of the lower cranial nerves, multiple small perforating arteries to the brain stem, and the difficulty of obtaining adequate surgical exposure have made the surgical treatment of these aneurysms difficult (4–10). Endovascular treatment of vertebrobasilar junction aneurysms with Guglielmi detachable coils can provide an alternative method of treatment.

In general, saccular aneurysms of the vertebrobasilar junction that are associated with fenestration of the basilar artery occur infrequently (11). However, many vertebrobasilar junction aneurysms are associated with fenestrations, and the basilar artery is a common site of fenestration (12). The incidence of fenestration of the basilar artery is reported to be 1.3% to 6% in autopsy series (7, 13) and 0.02% to 0.6% in angiographic series (14–16). The discrepancy between the autopsy incidence and angiographic incidence of basilar artery fenestrations can be explained by the fact that in some fenestrations the divider is very thin and in most projections is angiographically occult. Additionally the aneurysm itself may obscure the fenestration, preventing angiographic recognition. The incidence of an aneurysm being present when a fenestration is noted is reported to be 7% (14); however, the incidence of a fenestration when a vertebrobasilar junction aneurysm is present is reported to be 35.5% (11). Therefore, when a vertebrobasilar junction aneurysm is present, an associated fenestration should be strongly suspected.

Basilar artery fenestration occurs when there is a failure of the paired fetal longitudinal neural arteries to fuse. This event occurs during the fifth week of fetal growth. Fenestration may occur anywhere along the course of the basilar artery where there is failure of this process (17). The most frequent site of basilar artery fenestration is in the proximal portion of the basilar artery.

The lateral walls of the fenestrated artery have a normal intrinsic architecture; however, the medial walls show septation dividing the vascular channel into two distinct channels. The medial walls of the fenestration have focal defects at both ends of the fenestration. The media are absent locally with discontinuity of elastin at the proximal end of the fenestration. The subendothelium is thickened distally and thinned proximally. These structural changes at the proximal end of the fenestration are similar to those seen at cerebral artery bifurcations (18–20). The changes in the subendothelial structures are consistent with those produced by hemodynamic stress (20). The anatomic, structural, and hemodynamic changes that occur at the proximal end of the fenestration are consistent with the theory of the cause of intracranial berry aneurysms, as proposed by Stehbens, and may account for the apparent association of aneurysms and fenestrations at this site (21).

The geometry of fenestrations produces complex hemodynamics. Angiography in our patients demonstrated angiographic patterns that had a direct impact on the patients' diagnosis and treatment. Recognition of these angiographic patterns were important and varied. In some cases, the initial aneurysm and fenestration could be seen by injection of only one vertebral artery. Angiographic visibility of the aneurysm and fenestration could change as the hemodynamics changed, usually beginning after partial occlusion of the aneurysm. Angiographic compartments of some aneurysms demonstrated better opacification by injection of a specific vertebral artery. During coil placement, access to these compartments was usually most easily obtained via the specific vertebral artery that opacified them. The fenestration may not be apparent initially but may become apparent only after some degree of aneurusm occlusion. These hemodynamic and angiographic patterns require angiography of both vertebral arteries for complete evaluation of a vertebrobasilar junction aneurysm and associated fenestration. Treatment with Guglielmi detachable coils may require access via both vertebral arteries, and posttreatment evaluation requires that both vertebral arteries be imaged angiographically to exclude any residual aneurysm.

Conclusions

Vertebrobasilar junction aneurysms are frequently associated with fenestrations. The structural, geometric, and hemodynamic changes and their similarity to cerebral artery bifurcations may explain the association of vertebrobasilar junction aneurysms with fenestrations. The complex hemodynamics that exist within these aneurysms make it necessary that both vertebral arteries be imaged to ensure that the complete aneurysm is identified, the fenestration recognized, and no residual aneurysm remains after treatment. Vertebrobasilar junction aneurysms with associated fenestrations can be successfully treated with Guglielmi detachable coils with good results.

References

1. Guglielmi G, Viñuela F, Duckwiler G, et al. Endovascular treatment of posterior circulation aneurysms by electrothrombosis using electrically detachable coils. *J Neurosurg* 1992;515–524
2. Guglielmi G, Viñuela V, Sepetka I, et al. Electrothrombosis of saccular aneurysms via endovascular approach, I: electrochemical basis, technique, and experimental results. *J Neurosurg* 1991; 75:1–7
3. Guglielmi G, Viñulea F, Dion J, et al. Electrothrombosis of saccular aneurysms via endovascular approach, II: preliminary clinical experience. *J Neurosurg* 1991;75:8–14
4. Becker DH, Hamilton RD. Saccular aneurysm associated with fenestrated basilar artery: case report. *Neurosurgery* 1979;5.6: 695–697
5. Drake CG. The surgical treatment of aneurysms of the basilar artery. *J Neurosurg* 1968;29:436–447

6. Hernesniemi J, Vapalahti M, Niskanen M, et al. Management outcomes for vertebrobasilar artery aneurysms by early surgery. *Neurosurgery* 1992;31.5:857–862
7. Hoffman WF, Wilson CB. Fenestrated basilar artery with associated saccular aneurysm. *J Neurosurg* 1979;50:262–264
8. Matricali B, van Dulken H. Aneurysm of fenestrated basilar artery. *Surg Neurol* 1981;15.3:189–191
9. Nakasu Y, Nakasu S, Kidooka M, et al. Aneurysm at the fenestration of basilar artery: case report. *Arch Jpn Chir* 1982;51.2:344–348
10. Sugita K, Kobayashi S, Takemae T, et al. Aneurysms of the basilar artery trunk. *J Neurosurg* 1987;66:500–505
11. Campos J, Fox AJ, Viñuela F, et al. Saccular aneurysms in basilar artery fenestration. *AJNR Am J Neuroradiol* 1987;8:233–236
12. Osborn RE, Kirk G. Cerebral artery fenestration. *Comput Radiol* 1987;141–145
13. Wollschlaeger G, Wollschlaeger PB, Lucas FV, et al. Experience and result with postmortem cerebral angiography performed as routine procedure of the autopsy. *AJR Am J Roentgenol* 1967; 101:68–87
14. Saunders WP, Sorek PA, Mehta BA. Fenestration of intracranial arteries with special attention to associated aneurysms and other anomalies. *AJNR Am J Neuroradiol* 1993;14:675–680
15. Takahashi M, Tamakama Y, Kishikana T, et al. Fenestration of the basilar artery: report of three cases and review of the literature. *Radiology* 1973;109:79–82
16. Teal JS, Rumbaugh CL, Bergeron RT, et al. Angiographic demonstration of fenestrations of the intracranial arteries. *Radiology* 1973;106:123–126
17. Padget DH. The development of the cranial arteries in the human embryo. *Contrib Embryol* 1948;32:205–261
18. Black SP, Ansbacher LE. Saccular aneurysm associated with segmental duplication of the basilar artery. *J Neurosurg* 1984;61: 1005–1008
19. Compton MR. The pathology of ruptured middle-cerebral aneurysms with special reference to the differences between the sexes. *Lancet* 1962;2:421–425
20. Finlay HM, Canham PB. The layered fabric of cerebral artery fenestration. *Stroke* 1994;25.9:1799–1806
21. Stehbens WE. Etiology of intracranial berry aneurysms. *J Neurosurg* 1989;.70:823–831