

Endovascular Treatment of Transverse-Sigmoid Sinus Dural Arteriovenous Malformations Presenting as Pulsatile Tinnitus

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ABSTRACT

Transverse-sigmoid sinus dural arteriovenous malformations (DAVM) are uncommon vascular lesions for which complete cure may be difficult to obtain. A wide variety of treatments for these lesions include observation, arterial compression, surgical resection, and endovascular embolization. We propose that transverse-sigmoid sinus DAVM can be completely cured by occluding the ipsilateral dural sinus with detachable balloon and Guglielmi detachable coils (GDC) coils before arterial feeder embolization with histoacryl. Three patients who presented with pulsatile tinnitus and normal magnetic resonance imaging (MRI) studies underwent angiography, which demonstrated transverse-sigmoid sinus DAVM. All three patients were treated with retrograde transvenous sinus embolization with complete occlusion of the transverse-sigmoid sinus with detachable balloons and GDC coils with preservation of the vein of Labbé. Subsequently, the various feeders from the external carotid artery were embolized. The tentorial arteries arising from the ipsilateral internal carotid arteries were not embolized in any of the cases, which were still contributing to the DAVM. Complete cure with thrombosis of the tentorial branch of the internal carotid artery (ICA) was seen on follow-up angiogram 1 day after embolization in one patient and on 4-week and 6-week follow-up angiograms in the other two patients. Complete occlusion of the transverse sinus proximal to the vein of Labbé, in spite of incomplete arterial feeder embolization, can result in complete cure of the transverse

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sinus dural AVF if adequate time is given for the remaining feeders to occlude, once the fistula is obliterated.

KEYWORDS: AVM, endovascular treatment, tinnitis

Dural arteriovenous malformations (DAVM) are rare entities. Transverse-sigmoid sinus is the most common location for DAVM. Most DAVM in this region behave in a benign fashion. The patients usually have mild symptoms of headaches and pulsatile tinnitis. However, the tinnitis may progress and become intolerable. DAVM are also believed to be a dynamic disease process that carries the potential of malignant transformation. Some investigators believe that patients with unbearable symptoms should be offered aggressive treatment.^{1,2}

Ligation of feeder vessels rarely provides adequate treatment for these lesions and has been abandoned.^{3,4} Surgical resection of the involved sinus was usually offered to those few who had serious neurologic deficits but was fraught with excessive bleeding and was also not consistently curative for these cases. Endovascular therapy has evolved to offer improved success for these lesions. Transarterial embolizations were first tried with mixed success because of the difficulty in occluding all the small feeders to the DAVM and early recanalization of the occluded feeders.

Attention has recently been drawn to occlusion of the transverse-sigmoid sinus to treat these lesions and several investigators have seen good results.^{3,5-7} To add to the growing literature supporting the transvenous route of treatment for transverse sigmoid sinus DAVM, this report contains three cases treated in this manner. We present three patients with transverse-sigmoid sinus DAVM with intolerable bruits and pulsatile objective tinnitis. These patients underwent transvenous obliteration of the transverse sigmoid sinus, followed by partial transarterial embolization of the

feeders, and attained complete angiographic and clinical cure of their lesions.

METHODS AND RESULTS

Case 1

HISTORY AND PHYSICAL EXAMINATION

A 56-year-old woman presented with an 8-month history of right-sided throat and ear pain. Two months afterward, she began to experience pounding in her right ear. She did not lose hearing or develop headaches or vertigo. Her past medical history was significant for hypothyroidism and sensorimotor polyneuropathy. The physical examination was unremarkable, and there were no audible bruits over the right side of her head. Magnetic resonance imaging (MRI) displayed what appeared to be an arachnoid cyst on the right temporal region, but was otherwise normal.

ANGIOGRAM

Angiogram showed a right transverse-sigmoid sinus DAVM supplied by the tentorial branch from the right internal carotid artery (ICA) and by branches from the right occipital, middle meningeal, superficial temporal arteries, and left occipital and superficial temporal arteries (Fig. 1A). Selective injection of the right occipital and right internal maxillary arteries demonstrated that this DAVM had multiple holes with drainage into the right transverse and sigmoid sinuses and right in-

ternal jugular vein with no leptomeningeal flow. The patient underwent embolization of DAVM with balloon occlusion of the right transverse sinus along with embolization of arterial feeders.

PROCEDURE

The procedure was performed under general anesthesia. A 7 Fr sheath was introduced into the right common femoral artery. A second 7 Fr sheath was

introduced into the left femoral vein. The procedure was performed with the patient fully heparinized. A 6 Fr guiding catheter was placed in the proximal right external carotid artery. Through the guiding catheter, a microcatheter was introduced coaxially and the occipital artery selectively catheterized. Through the femoral venous sheath, a guiding catheter was placed with its tip in the left distal internal jugular vein. Through the guiding catheter, a detachable silicon balloon was coaxially

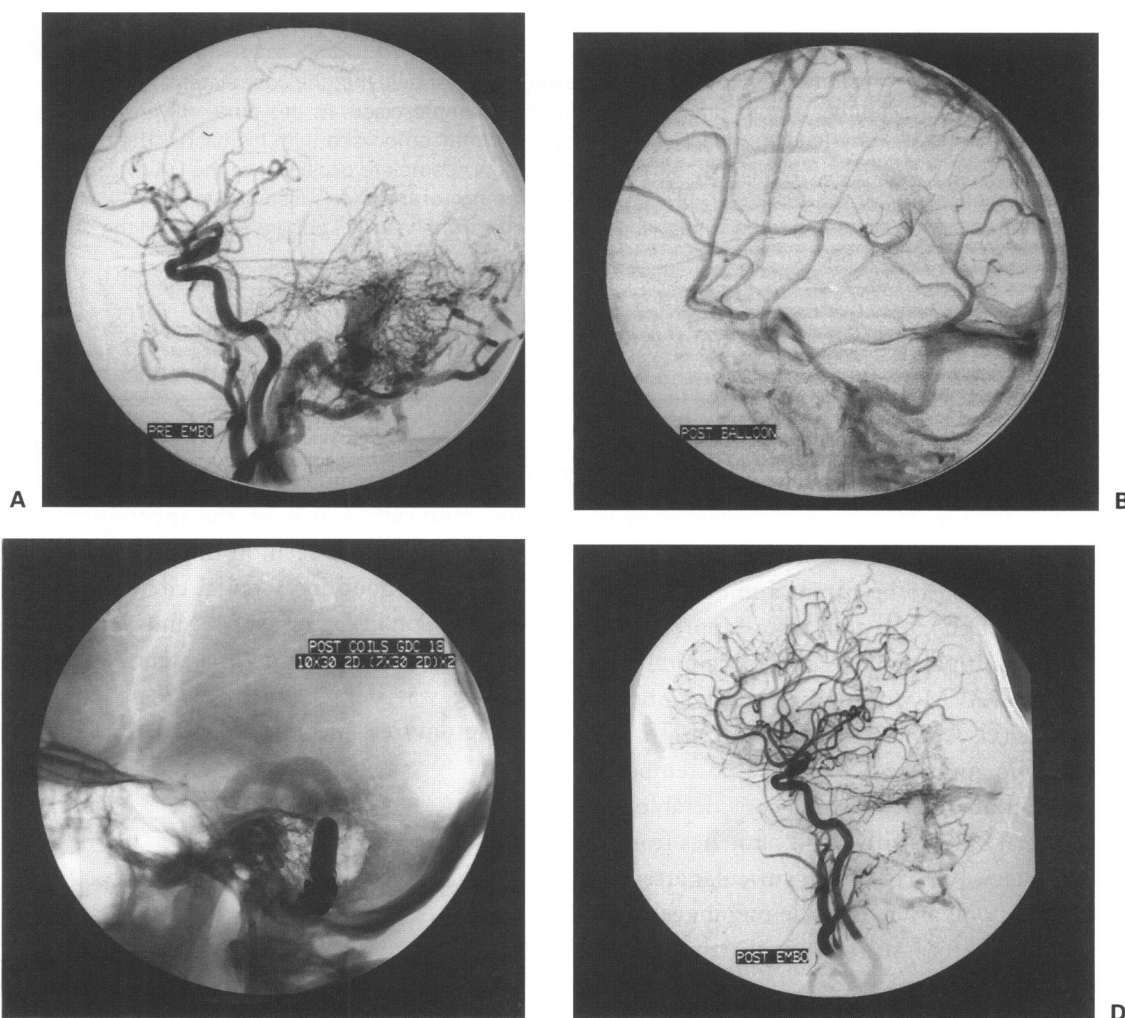


Figure 1 Case 1. (A) Pre-embolization angiogram shows a right transverse-sigmoid DAVM supplied by the tentorial branch from the ICA and by branches from the occipital, middle meningeal, and superficial temporal arteries. (B) Patient underwent embolization of DAVM with balloon occlusion of the transverse sinus. (C) Multiple GDC coils were also placed within the sinus. (D) Near-complete occlusion of the transverse sinus was obtained.

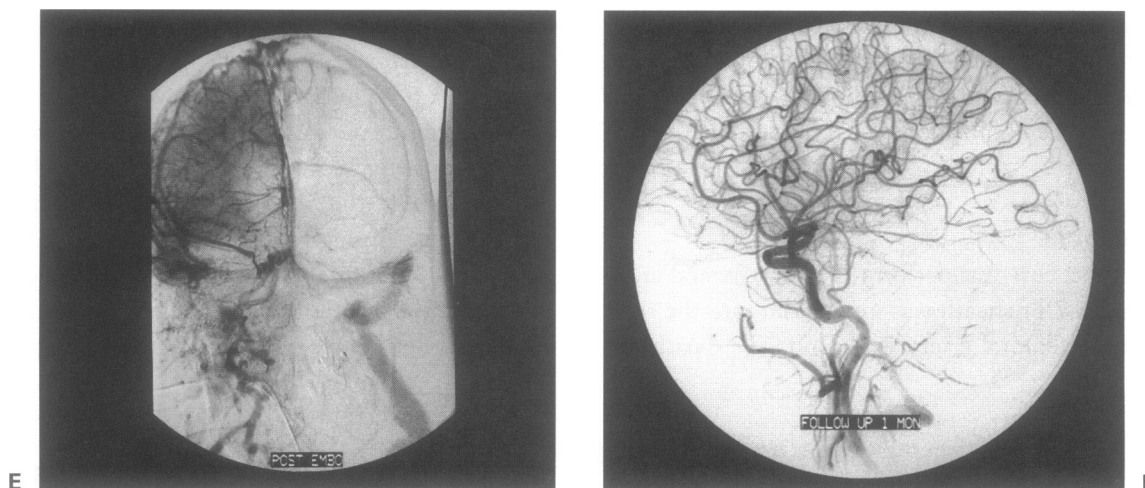


Figure 1 (Continued) (E) Postembolization venous phase angiogram shows that the contralateral transverse sinus was filling retrogradely indicating that venous drainage would not be compromised. At this time, only 70% of the multiple pedicles of the occipital artery feeding the DAVM were subsequently embolized with histoacryl. The plan was to embolize more feeders in 6 weeks. (F) Follow-up study 6 weeks shows complete occlusion of the DAVM. No arterial feeders from any of the previous vessels are visible. The tentorial branch of the ICA is also not seen. Coils and balloon remained in the transverse sinus in good position, and the patency of the vein of Labbé was seen on the venous phase.

introduced, and the left transverse sinus was occluded just proximal to the insertion of the vein of Labbé (Fig. 1B). Subsequently multiple GDC coils were placed within the transverse sinus to occlude the transverse sinus and the venous drainage of the DAVM (Fig. 1C). Near-complete occlusion of the transverse sinus was obtained, and the vein of Labbé was seen to be patent and draining normally (Fig. 1D,E). At this time, approximately 70% of the multiple pedicles of the occipital artery feeding the DAVM were subsequently embolized with histoacryl. A total of five embolizations were performed in multiple feeders. A postembolization angiogram demonstrated considerable flow through the DAVM with small branches from the tentorial artery, ICA, posterior auricular artery, superficial temporal artery, middle meningeal artery, and occipital artery still supplying the DAVM. The plan was to embolize more feeders in 6 weeks. The patient awoke from general anesthesia in stable neurologic condition with no deficits, remained in good condition, and was discharged the next day.

FOLLOW-UP EVALUATION

Angiogram 6 weeks later demonstrated complete occlusion of the right transverse sinus DAVM (Fig. 1F). No arterial feeders from any of the previous arteries were visible. Angiogram also did not show the tentorial branch of the meningohypophyseal trunk, which was seen on the previous angiogram. There was good intracranial circulation. The coils and balloon in the transverse sinus remained in satisfactory position, and the patency of the vein of Labbé was demonstrated. The patient remained symptom free since the embolization.

Case 2

HISTORY AND PHYSICAL EXAMINATION

The patient is a 57-year-old woman who previously underwent cosmetic surgery with left scalp incision presented with a 5-month history of left-sided pulsatile tinnitus. She did not have any visual changes or headaches, or any pain other than head-

aches. Patient denied any headache, visual changes, pain, or tenderness. MRI and magnetic resonance angiography (MRA) showed no significant findings. The past medical history was unremarkable with no previous history of bruising or bleeding tendencies. On physical examination, the patient had no unusual findings, including no bruits over the mastoid or postauricular area.

ANGIOGRAM

Angiogram demonstrated the left occipital artery and the left middle meningeal artery draining posteriorly into a transverse-sigmoid sinus DAVM (Fig. 2A). There was also retrograde flow into the opposite transverse sinus, and no leptomeningeal drainage was seen (Fig. 2B).

PROCEDURE

Treatment was performed in this patient in a similar fashion to the first patient. Multiple coils were placed into sigmoid sinus to occlude the dural fistula (Fig. 2C). After histoacryl embolization of the arterial feeders, angiogram demonstrated complete obliteration of the DAVM (Fig. 2D,E). After the procedure, the patient stated that her tinnitus had completely disappeared. She developed no focal neurologic deficits and was discharged to home in 2 days. The patient has been free of symptoms 1 year from her embolization.

Case 3

HISTORY AND PHYSICAL EXAMINATION

The patient is a 57-year-old woman who experienced "swishing" in her right ear for 6 months. A workup was performed at an outside institution, demonstrating a right transverse-sigmoid sinus DAVM. Her past medical history was unremarkable. The physical examination was significant for only a dilated vein in the right postauricular region.

ANGIOGRAM AND PROCEDURE

The right ICA angiogram demonstrated tentorial branches of the internal carotid artery supplying a transverse-sigmoid DAVM (Fig. 3A). Catheterization of the right external carotid artery demonstrated multiple branches of the external carotid artery, namely, the occipital artery, posterior auricular artery, and middle meningeal artery supplying the DAVM (Fig. 3B). Treatment was performed in this patient in a similar fashion as the first two patients. The transverse-sigmoid sinus was packed with multiple GDC coils (Fig. 3C). Histoacryl embolization was performed, and postembolization angiogram showed reduction in the flow to the DAVM (Fig. 3D).

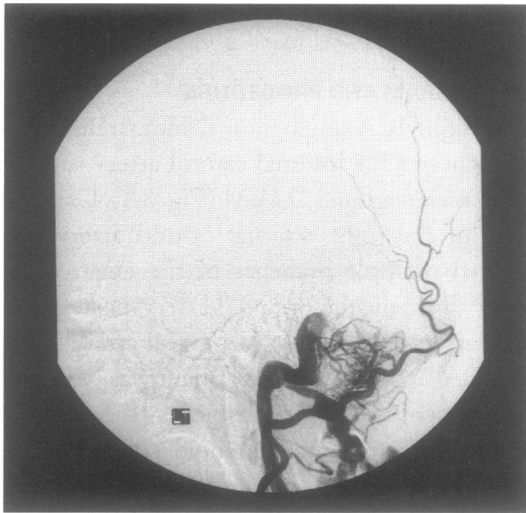
FOLLOW-UP EVALUATION

Angiogram at 6 weeks and 9 months showed complete thrombosis of the thrombosis seen in the right posterior DAVM (Fig. 3E,F). No arterial feeders or early draining veins were identified. Patient remained asymptomatic for 9 months since her embolization.

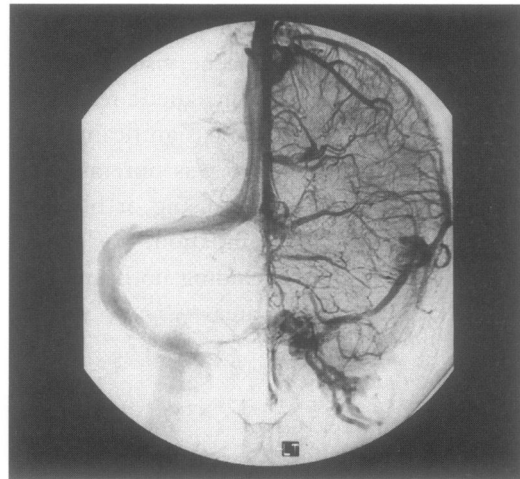
DISCUSSION

Intracranial skull base DAVM are uncommon vascular lesions, which have a variable presentation and often dramatic angiographic appearance. A wide variety of treatment options are available. Complete cure may be difficult to obtain, however. Of all intracranial DAVM, those that drain into the transverse and sigmoid sinus are the most common.⁹⁻¹² Fortunately, these types also have the most benign course.

The venous drainage pattern of a DAVM is the most important predictor of hemorrhagic stroke. Understanding the venous architecture is useful in developing the most appropriate endovascular and surgical treatment. For this reason, a classification scheme of transverse and sigmoid sinus



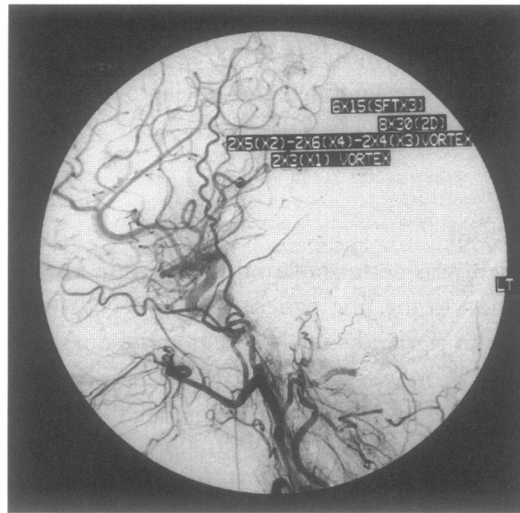
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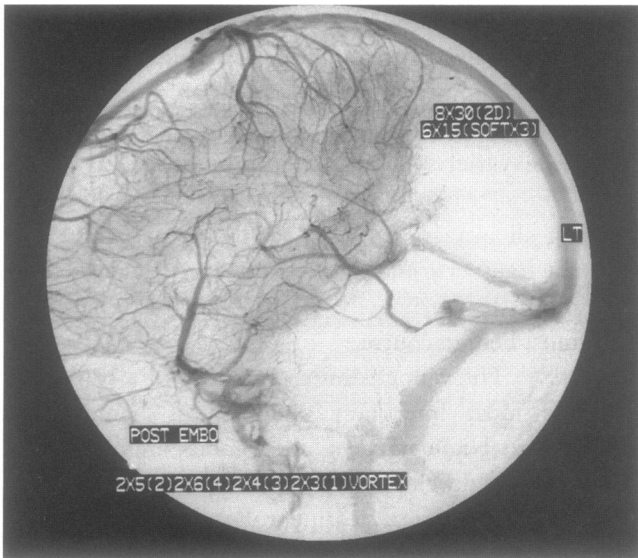
B



C



D



E

Figure 2 Case 2. (A) Pre-embolization angiogram demonstrates a dilated left occipital artery with multiple feeders draining anteriorly into a transverse-sigmoid sinus DAVM. (B) Retrograde flow into the opposite transverse sinus, and no leptomeningeal drainage. (C) Silicon balloon in the transverse-sigmoid sinus. (D) Postembolization angiogram shows complete obliteration of the DAVM. (E) Venous phase shows preservation of vein of Labbé.

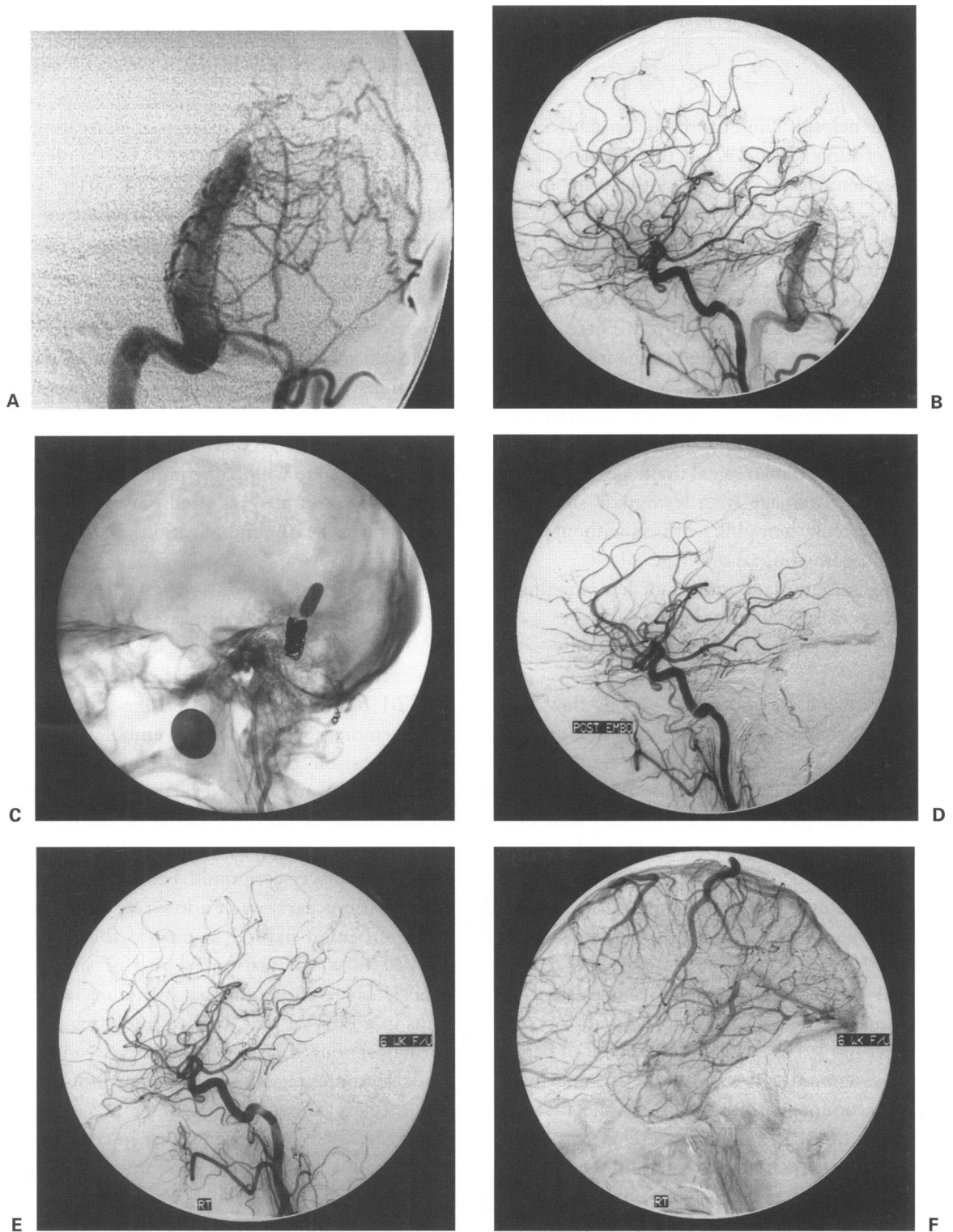


Figure 3 Case 3. (A) Pre-embolization angiogram shows multiple feeders from the ECA mainly the occipital artery. (B) Tentorial branch from the ICA drains into the transverse-sigmoid sinus. (C) A silicon balloon and GDC coils placed in the transverse sigmoid sinus. Subsequently, multiple branches of the occipital artery feeding the DAVM were injected with histoacryl. (D) Postembolization angiogram shows significantly decreased flow to the DAVM. This patient did well after the procedure and returned in 6 weeks for follow-up angiogram. (E,F) Complete thrombosis of the previously seen posterior DAVM with preservation of vein of Labbé.

DAVM is helpful. Djindjian and Merland's classification of DAVMs in 1978 is the original classification system upon which all others are based.⁸ Other investigators have modified Djindjian and Merland's classification for DAVMs of the transverse-sigmoid sinus.⁹ Four to five different types of transverse-sigmoid DAVMs based on the direction of venous blood flow are recognized. These classification schemes can be distilled to the following.

1. Normal antegrade drainage into the transverse or sigmoid sinus without any retrograde sinus or retrograde leptomeningeal drainage
2. Antegrade drainage with retrograde sinus flow to the torcula herophili with or without retrograde leptomeningeal drainage
3. Retrograde sinus and retrograde leptomeningeal drainage without any antegrade drainage
4. Retrograde leptomeningeal drainage only

Any evidence of cortical venous flow from the DAVM increases the chances of hemorrhagic stroke, edema, and ischemia.^{9,10} Our three patients had normal antegrade flow but no leptomeningeal flow from their DAVM. Therefore, they were classified as having the first type of DAVM, considered more of the benign type.

The natural history of benign DAVM shows that these benign variants can be followed conservatively for the most part because the likelihood of intracranial hemorrhage is virtually nonexistent.^{10,11} Furthermore, compression of carotid and/or occipital arteries has led to successful treatment of benign transverse-sigmoid sinus DAVM.^{12,13} Some investigators recommend this therapy as the first line of treatment.^{2,9} Patients who develop intolerable symptoms and/or debilitating signs, however, should be offered palliative embolization.^{1,2,14} Our three cases were offered treatment because of unbearable tinnitus.

Spontaneous thrombosis and complete closure of a transverse-sigmoid sinus DAVM is rare, but it has been reported.¹⁵⁻²¹ Delayed complete

thrombosis of DAVM after partial treatment of DAVM has also been reported.^{15,22} Complete cure of a transverse-sigmoid DAVM after partial transarterial treatment has been reported in a few patients.^{12,13,22,23} Treatment of transverse-sigmoid sinus DAVM with transarterial feeder embolization alone, however, is proving to have a low cure rate. ApSimon et al.¹ had only 2 of 11 patients and Bavinzski et al.²² had only two of seven patients with transverse-sigmoid sinus DAVM with no retrograde leptomeningeal flow who had only partial closure of their DAVM after transarterial embolizations alone who had complete cure. In addition, Halbach et al.¹² reported only 59% cure rate with transarterial embolization of transverse-sigmoid DAVM.

Arterial embolization of a transverse-sigmoid sinus DAVM decreases the flow to the DAVM, but this effect is usually short-lived because the recruitment of other feeders to the DAVM often takes place relatively quickly.^{1,5,14} Furthermore, complete arterial embolization is not always possible because of the numerous feeders that are often present.¹ Nevertheless, transarterial embolization as the only mode of treatment has been recommended by some for these benign types of transverse-sigmoid because transarterial embolizations carry such a low rate of morbidity, and the benign natural history of these types of DAVM does not justify the risk of sinus sacrifice.⁹⁻¹¹ The argument is that by not occluding the sinus in a DAVM that drained into a major sinus, normal venous drainage is preserved and retrograde leptomeningeal drainage does not develop. Interestingly enough, Lalwani et al.⁹ concluded that a DAVM is a disease process in constant evolution and always has the potential to progress from a benign grade to a malignant grade. Although, benign DAVM have been reported to progress to more aggressive variants.^{2,14} For these reasons, we believe and recommend that for patients with unbearable symptoms that complete angiographic cure of the DAVM should be the

goal and can be achieved with virtually no morbidity and mortality.

The embolization of the drainage pathway is now recognized as important to successful treatment of DAVM. In the case of transverse-sigmoid sinus DAVM, occlusion of the sinus can be safely done because retrograde drainage to the opposite sinuses is often possible. This has been shown to be the effective and sometimes definitive treatment for these lesions by several investigators.^{3-7,14} Halbach et al.³ reported complete angiographic cure in 5 of 11 patients who underwent only transvenous embolization of the transverse-sigmoid sinus with either coils or glue. Using detachable balloons, Roy and Raymond⁷ reported complete angiographic cure of transverse-sigmoid sinus DAVM in four patients with sinus occlusion only and in three patients with combined sinus occlusion and transarterial embolization. Barnwell et al.⁵ reported a successful complete obliteration of a low-grade sigmoid sinus DAVM using both techniques as well. Urta-sun et al.¹⁴ had 16 patients with transverse-sigmoid sinus DAVM treated via the transvenous route, which is the largest series. They reported 80% angiographic cure and 90% clinical cure. We believe that transvenous occlusion of the involved transverse-sigmoid sinus is the treatment of choice, but we also believe that the above should be accompanied by transarterial embolization of arterial feeders of these benign type transverse-sigmoid sinus DAVM.

Barnwell et al.⁵ suggested that transarterial embolization precede the transvenous technique to reduce the pressure in the draining sinus and to prevent rupture of the sinus. Knowing that the likelihood of rupture of a thick-walled sinus was miniscule, we elected to nearly completely occlude the transverse sinus first. No adverse events were encountered. Transvenous route was undertaken first to allow the effective usage and control of histoacryl liquid adhesive to embolize the arterial feeders without having to worry about errant and

dangerous embolization of other vessels beyond the fistula.

We also used both a detachable balloon followed by GDC coils. This was done because of the known risk of balloons deflating as reported in all of the patients that Roy and Raymond⁷ treated with balloons for the same lesions. Placement of GDC coils distally after placement of balloons further ensures that the sinus remain occluded. To avoid only partial occlusion and turning a benign DAVM into an aggressive one, some interventionists in response to Roy and Raymond's⁷ report recommended against the use of balloons and suggested use of coils only. We have found no significant risk associated with transverse sinus sacrifice when the vein of Labbé is preserved and retrograde flow to the opposite side is seen. We believe that complete cure of benign transverse-sigmoid sinus DAVM is possible and recommend this philosophy in treating these DAVM with intractable and intolerable symptoms.

Occlusion of the transverse-sigmoid sinus carries certain risks. Transient vertigo associated with labyrinthine dysfunction is one of the most common morbidities associated with this procedure and has been reported by some.⁷ Transient complication rate with this procedure has been quoted to 10 to 15% and permanent complication rate of around 4% or 5%.^{3,14} Since there are only three patients in our series, our morbidity rate may not reflect the true morbidity rate of sinus occlusion in this disease process, but we were fortunate to have no morbidity of any kind in our patients.

This report contains three benign type transverse-sigmoid sinus DAVM with complete obliteration after partial endovascular treatments involving both transvenous and transarterial embolizations. These three patients presented with pulsatile tinnitus and negative imaging studies and then underwent angiogram, which demonstrated transverse-sigmoid sinus dural AVF. All three patients were first treated with retrograde transve-

nous sinus embolization with complete occlusion of the transverse sinus with detachable balloons and GDC coils with preservation of the vein of Labbé. Subsequently, the various feeders from the external carotid artery were embolized. The tentorial artery arising from the ipsilateral internal carotid artery was not embolized in two cases, which was still contributing to the AVF. Subsequent angiograms showed complete occlusion of the DAVM.

CONCLUSIONS

Complete occlusion of the transverse sinus proximal to the vein of Labbé, in spite of incomplete arterial feeder embolization, can result in complete cure of benign types of transverse-sigmoid sinus DAVMs if adequate time is given for the remaining feeders to occlude once the fistula is obliterated. Because of the low morbidity associated with this procedure, we recommend transvenous obliteration of the transverse sinus followed by transarterial occlusion of arterial feeders for benign DAVM of the transverse-sigmoid sinus that have adequate contralateral venous drainage.

REFERENCES

1. ApSimon HT, Ives FJ, Khangure MS. Cranial dural arteriovenous malformation and fistula. Radiological diagnosis and management. Review of thirty four patients. *Aust Radiol* 1993;37:2-25
2. Cognard C, Gobin YP, Pierot L, et al. Cerebral dural arteriovenous fistulas: clinical and angiographic correlation with a revised classification of venous drainage. *Radiology* 1995;194:671-680
3. Halbach VV, Higashida RT, Hieshima GB, et al. Transvenous embolization of dural fistulas involving the transverse and sigmoid sinuses. *Am J Neuroradiol* 1989;10:385-392
4. Roy D, Lavigne F, Raymond J. Pulsatile tinnitus and dural arteriovenous fistula of the transverse sinus. *J Otolaryngol* 1993;22:409-412
5. Barnwell SL, Nesbit GM. Dural arteriovenous malformations of the transverse and sigmoid sinuses. *Tech Neurosurg* 1995;2:53-65
6. Okuizumi K, Watanabe K, Yamazaki M, et al. A case of dural arteriovenous malformation associated with progressive dementia showing marked improvement with endovascular treatment [in Japanese]. *Rinsho Shinkeigaku Clin Neurol* 1998;38:112-117
7. Roy D, Raymond J: The role of transvenous embolization in the treatment of intracranial dural arteriovenous fistulas. *Neurosurgery* 1997;40:1133-1141; discussion 1141-1144
8. Djindjian R, Merland JJ. Super-selective arteriography of the external carotid artery. New York: Springer-Verlag; 1978
9. Lalwani AK, Dowd CF, Halbach VV. Grading venous restrictive disease in patients with dural arteriovenous fistulas of the transverse/sigmoid sinus. *J Neurosurg* 1993;79:11-15
10. Borden JA, Wu JK, Shucart WA. A proposed classification for spinal and cranial dural arteriovenous fistulous malformations and implications for treatment. *J Neurosurg* 1995;82:166-179
11. Davies MA, Saleh J, Ter Brugge K, et al. The natural history and management of intracranial dural arteriovenous fistulae. *Int Neuroradiol* 1997;3:295-302
12. Halbach VV, Higashida RT, Hieshima GB, et al. Dural fistulas involving the transverse and sigmoid sinuses: results of treatment in 28 patients. *Radiology* 1987;163:443-447
13. Shah SB, Lalwani AK, Dowd CF. Transverse/sigmoid sinus dural arteriovenous fistulas presenting as pulsatile tinnitus. *Laryngoscope* 1999;109:54-58
14. Urtasun F, Biondi A, Casaco A, et al. Cerebral dural arteriovenous fistulas: percutaneous transvenous embolization. *Radiology* 1996;199:209-217
15. Bitoh S, Sakaki S. Spontaneous cure of dural arteriovenous malformation in the posterior fossa. *Surg Neurol* 1979;12:111-114
16. Endo S, Kosu K, Suzuki J. Spontaneous regression of posterior fossa dural arteriovenous malformation. *J Neurosurg* 1979;51:715-717
17. Ito Y, Fukumura A, Seto H, et al. Internal carotid aneurysmal formation following spontaneous regression of the dural arteriovenous malformation in the posterior fossa—a case report [in Japanese]. *No Shinkei Geka Neurol Surg* 1985;13:1215-1220
18. Kutluk K, Schumacher M, Mironov A. The role of sinus thrombosis in occipital dural arteriovenous malformations—development and spontaneous closure. *Neurochirurgia* 1991;34:144-147
19. Magidson MA, Weinberg PE. Spontaneous closure of a dural arteriovenous malformation. *Surg Neurol* 1976;6:107-110
20. Pritz MB, Pribram HF. Spontaneous closure of a high-risk dural arteriovenous malformation of the transverse sinus. *Surg Neurol* 1991;36:226-228
21. Rohr J, Gauthier G. Spontaneous regression of a dural arteriovenous fistula of the posterior fossa. [in French]. *Rev Neurol* 1985;141:240-244

22. Bavinski G, Richling B, Killer M, et al. Evolution of different therapeutic strategies in the treatment of cranial dural arteriovenous fistulas—report of 30 cases. *Acta Neurochir (Wien)* 1996;138:132–138
23. Kurl S, Vanninen R, Saari T, Hernesniemi J. Development of right transverse sinus dural arteriovenous malformation after embolization of a similar lesion on the left. *Neuroradiology* 1996;38:386–388