Dural Arteriovenous Fistula After Cerebral Sinus Thrombosis
A Case Study of Serial Venous Transcranial Color-Coded Sonography

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Dural sinus thrombosis has been proposed as the primary event in the formation of a dural arteriovenous fistula (DAVF). However, the temporal course of development of a DAVF after cerebral sinus thrombosis has rarely been shown clinically. Venous angiography is a sensitive method for evaluating sinus thrombosis. Venous transcranial color-coded sonography (TCCS) has been used to detect changes in venous flow in patients with sinus thrombosis. Venous TCCS may serve as a useful, noninvasive, cost-effective examination technique for the follow-up of patients with cerebral sinus thrombosis. It also provides information on venous hemodynamics related to outcome, but clinical experience is limited.

We report a case of an acquired DAVF after intrasinus thrombolysis for cerebral venous sinus thrombosis. Venous TCCS showed sequential changes in venous blood flow, indicating venous sinus hypertension and the occurrence of an abnormal arteriovenous connection.

Case Report

A 54-year-old man had a sudden severe headache over the occipital regions extending to the forehead, and he was admitted to Veterans General Hospital–Taichung. Magnetic resonance (MR) imaging was performed 4 days after admission and showed thrombosis over the superior sagittal sinus and bilateral transverse sinuses (Figure 1, A and B). Because of the onset of progressive drowsiness and right limb weakness, cerebral angiography was performed 2 days later and disclosed occlusion of the superior sagittal and bilateral transverse sinuses (Figure 2A). The superior and bilateral transverse sinuses were successfully reopened after intrasinus injection of 720,000 U of urokinase. No abnormal arteriovenous connection was found during the procedure (Figure 2B). For sonographic examinations, a phased array color-coded sonography system (Sonos 5500; Hewlett-Packard) was used.
**Figure 1.** Sagittal longitudinal relaxation time-weighted imaging after gadolinium enhancement (A) showed a filling defect from the thrombi within the superior sagittal sinus. Two-dimensional time of flight MR angiography (B) showed poor visualization of the superior sagittal sinus and bilateral transverse sinus. Follow-up 2-dimensional time of flight angiography 1 month later (C) showed reopening of the superior sinus and both transverse sinuses. Follow-up 2-dimensional time of flight MR angiography 15 months later (D) showed abnormal engorged tangling vessels over posterior head regions.
Figure 2. The venous phase of digital subtraction angiography (A) showed poor visualization of the superior sagittal sinus and both transverse sinuses from venous occlusion and prominence of the cortical veins from collateral circulation. The arterial phase of digital subtraction angiography (B) showed no abnormal arteriovenous connection. The follow-up arterial phase of digital subtraction angiography 15 months later (C) showed an arteriovenous fistula over the posterior head region. A venous angiogram (D) showed stenosis over the bilateral transverse sinus and right sigmoid sinus.
Company, Palo Alto, CA) equipped with a 2.0-MHz transducer was used. The intracranial venous system was insonated through a temporal acoustic bone window as described elsewhere. Venous TCCS showed normal flow velocities and direction in the bilateral basal veins 3 days after thrombolysis (Figure 3A). The patient was discharged 2 weeks later with mild clumsiness of the right hand. He received regular warfarin treatment (5–7.5 mg once a day) to maintain prothrombin time in an adequate therapeutic range (international normalized ratio, 2.16–3.50).

Ten months later, TCCS showed reversal of the flow direction in both basal veins (Figure 3B). However, follow-up MR imaging showed no recurrence of thrombosis or abnormal arteriovenous shunting (Figure 1C). The Doppler flow waveform of the bilateral basal veins showed reversal and arterIALIZATION 15 months after thrombolytic therapy (Figure 3, C and D). Magnetic resonance angiography disclosed abnormal engorged and tangled vessels and early opacification of the deep venous system (Figure 1D). Cerebral angiography showed DAVF with venous drainage through both transverse and sigmoid sinuses to the straight sinus, internal cerebral veins, and basal veins (Figure 2C) and segmental stenosis of both transverse and right sigmoid sinuses (Figure 2D). There was no subjective discomfort or new neurologic deficit during the follow-up period.

Figure 3. Normal Doppler flow velocities and direction were shown 3 days after thrombolysis (A). The flow direction became reversed 10 months after thrombolysis (B). Fifteen months after thrombolysis, the Doppler flow waveform became arterialized, and diastolic flow velocities decreased with mild neck compression (C). Color B-mode imaging (D) showed the normal posterior cerebral artery (blue) and a reversed flow direction in the basal vein (red). The downward arterial Doppler signals shown in B and C were detected from the adjacent posterior cerebral artery.

A

B

C

D
Discussion

Our findings show that venous TCCS is a useful technique for detecting disturbance of cerebral venous circulation and for follow-up of patients with cerebral venous sinus thrombosis. Valuable information such as flow direction and changes in the Doppler flow waveform, which cannot be routinely obtained by time-of-flight MR angiography, can be recorded easily and noninvasively with venous TCCS. Although TCCS cannot examine all the intracranial venous structures, it can serve as a complementary examination technique, providing hemodynamic information on venous circulation.

The cerebral venous system is a network of interconnecting channels. The direction of blood flow depends on a pressure gradient. The paired basal veins of Rosenthal normally join the vein of Galen and then drain into the straight sinus. A reversed flow direction in the basal veins of Rosenthal indicates high venous pressure or thrombosis in the transverse and straight sinuses. Reversal of the flow direction in the basal veins of Rosenthal has been reported only in rare cases of straight sinus thrombosis. Because MR imaging showed no reocclusion of sinuses, reversal of the flow direction in the basal veins most likely resulted from elevated venous sinus pressure. Once the Doppler flow waveform of the basal veins of Rosenthal becomes arterialized, the diagnosis of an arteriovenous shunt is straightforward.

The growth of dural arteries during thrombus organization or underlying dural vascular weakness has been proposed to predispose to the development of DAVFs. Previous investigators have shown sinus hypertension in the development of dural arteriovenous malformations in animal studies. In our patient, segmental narrowing over the bilateral transverse sinuses and right distal sigmoid sinus resulted in venous sinus hypertension, which in turn led to a pressure-dilatation-activated growth mechanism of the small dural vessels or ischemia-related aberrant angiogenesis. In our patient, we documented elevated venous pressure in a developing DAVF. The question of whether persistent disturbance of cerebral venous flow is a risk factor for later development of DAVF requires further study.

The relationship between neuroradiologic intervention and development of dural arteriovenous malformations is unclear. Catheter-related microtrauma could result in the development of a DAVF. High-pressure injection of contrast and thrombolytic agents during intervention might cause forced opening of a minute arteriovenous shunt, which is normally present within the dura mater. The treatment of stenosis of dural sinuses and DAVFs is highly challenging. Intrasinus stenting can be helpful for relieving elevated sinus pressure but may lead to a greater arteriovenous pressure gradient and shunt flow. Arterial embolization of a DAVF without relief of venous hypertension can give rise to another fistula. We recommended intermittent carotid arterial compression for such a case. We also plan gamma knife stereotactic surgery for DAVFs and percutaneous angioplasty for venous sinus stenosis.

In conclusion, venous TCCS is useful for follow-up of selected patients with sinus thrombosis. The finding of venous hypertension should prompt careful surveillance for venous stenosis and the ensuing development of a DAVF.

References


