Increased Cerebral Perfusion After Detachable Balloon Embolization of Carotid Cavernous Fistula on Technetium-99m-HMPAO Brain SPECT

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Most symptoms and signs associated with a carotid cavernous fistula (CCF) are thought to be related to regurgitation of flow into cortical veins and to venous congestion. Arteriovenous shunting and secondary perfusion insufficiency is regarded as less important in causing symptoms. We describe a 27-yr-old male patient who had improvement of neurologic symptoms and signs after detachable balloon embolization of traumatic CCF. The pre- and postocclusion ^{99m}Tc-HMPAO brain SPECT scan showed improved cerebral blood flow after occlusion. The CCF had shown marked arteriovenous shunting without significant venous congestion on pre-occlusion cerebral angiogram. The postocclusion cerebral angiogram revealed complete occlusion of the CCF with increased blood flow in the ipsilateral middle cerebral artery distribution. These findings suggest that cerebral dysfunction may be related to perfusion insufficiency from the CCF. Brain SPECT scanning can assess the functional status of cerebral perfusion and may be a useful, noninvasive adjunct to angiography.

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Most symptoms and signs in patients with a carotid cavernous fistula (CCF) are thought to be associated with regurgitation of arterial blood into cortical veins and venous congestion from the CCF (*1–4*). A steal phenomenon, though less common, can also cause significant secondary dysfunction of the central nervous system due to decreased cerebral perfusion (*1,5*). In this case, embolization of the CCF with a detachable balloon in the internal carotid artery will not only occlude the fistula tract but will also improve cerebral perfusion by eliminating the source of steal (*6*).

We report a case demonstrating the usefulness of SPECT brain imaging performed before and after detachable balloon embolization of the CCF and internal carotid artery.

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CASE REPORT

A 27-yr-old male was admitted with a 3-mo history of painful exophthalmos of the right eye, chemosis of the conjunctiva and mild left hemiparesis that developed 3 mo previously after a motor vehicle accident. On physical examination, a pulsation was felt over his right eyeball with bruit.

A contrast-enhanced CT study (Fig. 1) of the orbit and skull base showed a fullness in the right cavernous sinus with a dilated right superior ophthalmic vein. The CT findings, in the presence of the aforementioned symptoms and signs, raised the question of the presence of carotid cavernous shunting. A SPECT study of the brain was performed after an intravenous injection of 740 MBq (20 mCi) of ^{99m}Tc-hexamethylpropylene amine oxime (HMPAO) with eyes closed in a quiet room. SPECT was performed using a single-headed rotating gamma camera equipped with a low-energy, high-resolution, parallel-hole collimator. Sixty-four views were obtained at 5.6-degree angular increments with an acquisition time of 30 sec per view. The images were reconstructed on a dedicated computer into 64 × 64 image matrices using a Butterworth filter at an order of 5 (cut off frequency 0.5 cycle/cm). The SPECT scan demonstrated diffusely decreased perfusion in the right cerebral hemisphere.

Radioactivity of the right hemisphere was counted and compared with that of the contralateral homologous brain region. The left-to-right activity ratio was 1.1 (Fig. 2A). Four-vessel cerebral angiography was subsequently performed. There was no evidence of cerebral venous congestion. A lateral view of the vertebral angiogram revealed good collateral flow from the posterior cerebral artery to the internal carotid artery via the posterior communicating artery, retrograde flow into the infraclinoid and cavernous segments of the internal carotid artery and filling of the carotid cavernous fistula with visualization of the superior ophthalmic vein. There was decreased blood flow into the right middle cerebral artery (Fig. 2B).

The patient underwent a detachable balloon embolization of the CCF. Selective embolization of the CCF failed due to the acutely angulated cavernous segment of the internal carotid artery. Following this, balloon test occlusion of the right internal carotid artery was performed. The patient tolerated the procedure well and remained asymptomatic. Therefore, permanent total occlusion of the right internal carotid artery and CCF was performed

FIGURE 1. Contrast-enhanced axial CT scan shows a prominent right cavernous sinus with a dilated right superior ophthalmic vein (arrows).

with detachable balloons and coils. A lateral view of the vertebral angiogram obtained after the occlusion showed good collateral circulation through the posterior communicating artery and increased blood flow into the right middle cerebral artery with complete occlusion of the CCF (Fig. 3B). SPECT scans of the brain performed 2 wk later revealed increased perfusion in the entire right cerebral hemisphere. The left-to-right activity ratio was 0.94 (Fig. 3A). On physical examination 1 mo after the embolization procedure, the patient was completely asymptomatic with improvement of his left-sided weakness.

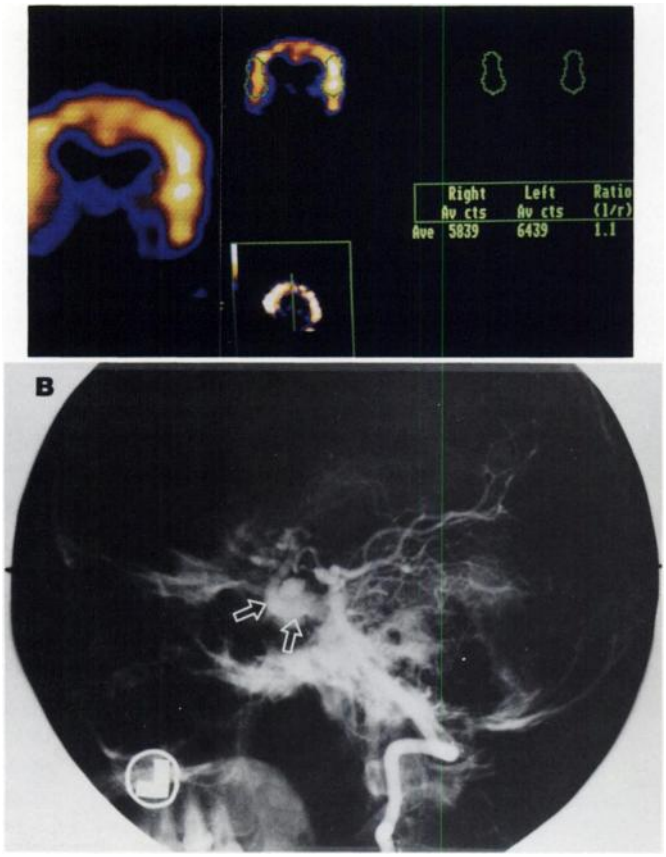

FIGURE 2. (A) The coronal image of pre-balloon embolization brain SPECT scan reveals diffusely decreased radioactivity in the right cerebral hemisphere compared with left cerebral hemisphere. Av cts = average counts and l/r = left/right. (B) On the lateral view of the vertebral angiogram before embolization, contrast filling of carotid cavernous fistula (arrows) is noted through the collateral circulation of the posterior communicating artery. Poor filling of the right middle cerebral artery was due to the "steal syndrome" of the carotid cavernous fistula.

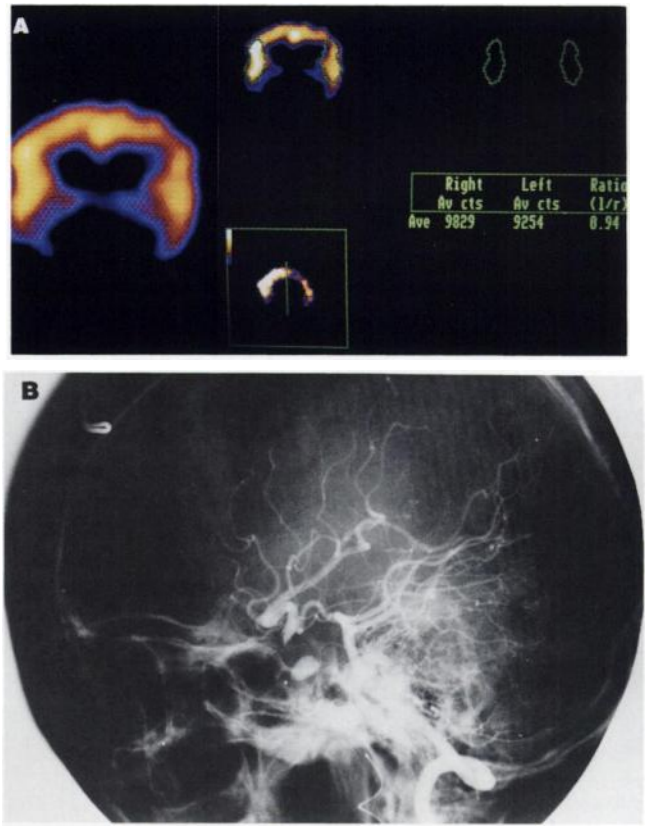

FIGURE 3. (A) The coronal image of postballoon embolization brain SPECT shows improvement of radioactivity in the right cerebral hemisphere. It suggests improvement of cerebral perfusion after balloon embolization of the carotid cavernous fistula. Av cts = average counts and l/r = left/right. (B) The lateral view of postballoon embolization angiogram shows obliteration of the carotid cavernous fistula and improvement of the blood flow in right middle cerebral artery distribution.

DISCUSSION

CCF may cause a variety of symptoms and signs such as exophthamos, chemosis, headache, diplopia, bruit and tinnitus. Many of these problems are reported to be related to regurgitation of flow into the cortical veins from the CCF and venous congestion (*1–4*). Cerebral hemorrhage, increased intracranial pressure with cortical venous hypertension, decreased visual function, progressive proptosis and cerebral ischemia may also complicate intracranial venous drainage (*4*). Steal of blood flow from the arterial system is thought to be a less significant cause of central nervous system dysfunction in patients with a CCF. However, steal can also decrease perfusion with significant dysfunction of the central nervous system (*1,5*).

The cerebral angiogram of the patient reported showed evidence of arteriovenous shunting through the CCF and drainage through the right superior ophthalmic vein. Brain SPECT clearly revealed diffusely decreased perfusion in

the right cerebral hemisphere. The combination of these findings suggests that the left hemiparesis may have resulted from right cerebral hemodynamic insufficiency. SPECT demonstrated increased blood flow to the right hemisphere after embolization of the right internal carotid artery and the CCF. The SPECT findings correlated well with the patient's marked clinical improvement.

In summary, steal phenomenon associated with a carotid cavernous fistula can cause significant neurological deficits that may improve after balloon embolization of the internal carotid artery or CCF. Brain SPECT scanning can assess the functional status of cerebral perfusion and may be a useful, noninvasive adjunct to angiography.

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