Technique of catheterization and embolization of the lenticulostriate arteries

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The technique of catheterization and embolization of the lateral and medial lenticulostriate arteries, using one or two balloon catheters of various designs, is described. A case of a bilateral thalamic arteriovenous malformation is presented and a further instance of an aneurysm of a striate artery is briefly discussed. Because of the high probability of proximal middle cerebral artery (MCA) thrombosis, care must be taken to determine tolerance to MCA occlusion prior to embolization.

KEY WORDS • aneurysm • arteriovenous malformation • balloon catheterization • embolization • isobutyl-2-cyanoacrylate • lenticulostriate artery

SINCE Brooks, et al., introduced transarterial embolization in the treatment of a carotid cavernous fistula in 1931, considerable advances have been made in transvascular occlusive techniques, particularly in recent years. The introduction of flow-guided balloon catheters and tissue adhesive of low viscosity has increased the possibilities of managing previously insoluble problems. The purpose of this manuscript is to report the successful catheterization and deliberate occlusion of lenticulostriate arteries involved in a bithalamic arteriovenous malformation (AVM) (Fig. 1).

Technique of Catheterization

We employed the femorocerebral approach, using Kerber's microballoon catheter, which has a single lumen and a calibrated-leak balloon at its distal end. It permits superselective catheterization, arrest of blood flow, and deposition of tissue adhesives. The catheterization of the lenticulostriate arteries can be performed with one or two catheter assemblies, each introduced via one femoral artery. The use of single- or double-catheter assemblies depends on the geometric linearity and the hemodynamic characteristics of the lesion, and the striate vessel to be catheterized (lateral or medial group).

Single-Balloon Catheter Technique

The embolization microballoon catheter is injected

FIG. 2. Coaxial superselective angiogram of a lateral lenticulostriate artery, frontal (left) and lateral (right) projections. The microballoon (large arrow) is arresting flow, while contrast material is injected into the striate artery. Note the introducer polyethylene outer catheter (small arrows).

FIG. 3. Subtraction angiogram, frontal view, during balloon occlusion of the right middle cerebral artery (MCA) to evaluate clinical tolerance to MCA occlusion.

coaxially through an introducer or outer catheter of No. 5.8 or 6.4 French thin-wall polyethylene,* which has been placed in the desired internal carotid artery (ICA) (Fig. 2). The microballoon usually flows into

the middle cerebral artery (MCA). A preliminary occlusive test of the middle cerebral trunk is performed to insure tolerance to MCA occlusion (Fig. 3). A control ICA angiogram can be useful to demonstrate anterior cerebral collateral vessels supplying the temporarily occluded MCA territory. If the patient does not tolerate MCA occlusion, and no anterior cerebral artery collaterals can be demonstrated, a superficial temporal to MCA bypass procedure can be performed prior to embolization. While occluding the MCA with a calibrated-leak balloon, two precautions are recommended. The first is the continuous use of heparinized perfusion, and the second is a slow, low-pressure injection to prevent rupture of the vessel.†

Once tolerance of MCA occlusion is known, the microcatheter is gently disengaged. This is accomplished by gentle withdrawal of the polyethylene introducer catheter. The microcatheter should not be pulled alone, because its thin elastic wall, which is made of silicone rubber, may rupture. The polyethylene introducer catheter will also permit more distal advancement of the microcatheter if necessary; the introducer is simply advanced into the ICA, which introduces more of the microcatheter into the circulation. The gentle inflation and deflation of the balloon will then permit the flow of blood to carry the calibrated microballoon more distally. The M₁ segment can be probed by withdrawing or advancing the catheter assembly until the lenticulostriate vessel is entered (Fig. 2). Optimal fluoroscopy and immediate

* Catheter manufactured by Elicath, P.O. Box 1214C, Rahway, New Jersey.

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Fig. 4. Frontal (left) and lateral (right) skull films demonstrating the radiopaque isobutyl-2-cyanoacrylate cast after two lateral lenticulostriate arteries were embolized.

life subtraction‡ are of great help during these maneuvers. Once the position of the catheter is confirmed, a very small quantity (0.1 to 0.2 cc) of radiopaque isobutyl-2-cyanoacrylate (IBCA) is injected (Fig. 4). This injection must be preceded by a nonionic injection of 5% dextrose in water to prevent early polymerization of the IBCA, and to avoid gluing the catheter to the vessel intima.‡

Two-Balloon Catheter Technique

The two-balloon catheter technique is used when the single-balloon catheter technique fails. This procedure is used for the more medial group of lenticulostriate arteries arising from the A1 segment.

Two techniques are possible. In the first, a double-lumen balloon catheter is introduced into the contralateral ICA to change the hemodynamic flow medially and to the opposite side (Fig. 5), while the microcatheter is carried by the blood flow into the ipsilateral ICA (Fig. 6). The second technique involves two microballoon catheters introduced into the same carotid artery through two different introducers. In this case, the first microballoon occludes the M1 seg-

‡Apparatus manufactured by Princeton Electronics, P.O. Box 101, N. Brunswick, New Jersey.
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Case Report

This patient was born after 7 months' gestation. He was well until the age of 7 years, when his teacher noted that he had poor manual dexterity bilaterally and difficulty in writing. He exhibited awkwardness, unusual behavior, and slurred speech. At 13 years of age, while playing tennis, he began to behave in a bizarre manner, ran around, then collapsed and had a grand mal seizure with eye-rolling, incontinence, and a postictal sleep period.

He was evaluated at another institution. Electroencephalography showed evidence of diffuse cerebral dysfunction. Brain scan at that time delineated a large area of bilateral uptake, suggesting a vascular disorder. A femorocerebral angiogram revealed a large bilateral symmetrical AVM at the level of the basal ganglia and thalami. It was deemed impossible to treat the AVM by surgery or embolization. After that, he deteriorated progressively; he was able to read the newspaper at 7 years old, but at the present admission could hardly read. His speech had become slurred and was poorly understood.

The patient was transferred to our care at the age of 17 years because of an acute change in his mental status with marked disorientation. Lumbar puncture was reported to be normal. Computerized tomography performed at the other institution showed the AVM, with no evidence of bleeding.

Fig. 6. Subtraction angiogram, frontal view, after catheterization of a medial lenticulostriate artery. The balloon (short arrow) has taken the shape of the vessel and is arresting flow. The two previously embolized striate vessels (curved arrows) are partially subtracted.

Fig. 7. Frontal (left) and lateral (right) skull films after the medial lenticulostriate artery has been embolized.
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The patient's father is schizophrenic, and his 13-year-old sister has epilepsy, which is controlled with Dilantin.

Examination. On admission, the patient was lethargic but arousable, with slow and slurred speech. He complained of nausea. He had mild left hemiparesis with brisk reflexes bilaterally and sustained clonus and a right Babinski sign. A bruit could be heard on both temporal areas.

Femorocerebral angiography revealed a bilateral thalamic and basal ganglionic AVM, supplied by both carotid circulations (Fig. 1) and the posterior perforating vessels. In view of the extent of the lesion and the progressive neurological deterioration with recent acute change, and since surgical, medical, or other form of treatment was not available to us, we decided on embolization in stages, in an attempt to arrest or slow the patient's rapid clinical deterioration.

Operations. The right anterior portion of the lesion was approached first, and is the subject of this report. An MCA occlusive test was carried out, followed by catheterization of a lateral lenticulostriate artery (Fig. 3). Embolization of the lateral lenticulostriate arteries was performed with radiopaque IBCA, using the single-catheter assembly technique (Fig. 4). At a second operation, a medial lenticulostriate vessel was catheterized using a double-lumen balloon catheter to temporarily occlude the left ICA so as to change the hemodynamic flow and facilitate medial lenticulostriate catheterization (Figs. 5 and 6). The postembolization cast is seen in Fig. 7.

Angiography immediately after the lateral striated vessels were embolized showed contrast material passing around the cast and preservation of the M1 portion of the MCA (Fig. 8). One week later, the medial lenticulostriate artery was embolized and the M1 segment thrombosed (Fig. 9). This procedure was carried out without clinical manifestation. The MCA terri-
FIG. 10. Subtraction angiogram, frontal view, of the left internal carotid artery in the late phase, after occlusion of three lenticulostriate arteries, and complete occlusion of the right middle cerebral artery (MCA) at the M₁ segment. The right MCA branches distal to the occlusion (arrows) fill via leptomeningeal collaterals from the anterior cerebral artery.

FIG. 11. Subtraction angiogram, frontal view, in the early arterial phase 2 years after the previous embolization, showing an aneurysm (arrow) not appreciated 2 years earlier.

Discussion

Catheterization and intentional occlusion of the lenticulostriate arteries is technically possible. Hilal and co-workers⁷ were able to catheterize a striate vessel with the use of a magnetically guided catheter with detachable tip, and Luessenhop⁸ has occluded lenticulostriate arteries with silicone spheres by first occluding the distal M₁ segment with a larger sphere.

Our technique uses flow-guided catheters, with one- or two-catheter assemblies, and the use of a tissue adhesive to create a cast of the malformation. The value of this technique in the management of deep ganglionic lesions, however, is not established. The AVM in our case involved both sides, and was quite extensive. The treatment of a more limited lesion with unilateral involvement, or the catheterization and embolization of a lenticulostriate artery participating in a hemispheric lesion (not infrequently encountered), now appears possible.

We have attempted to occlude a lenticulostriate vessel supplying an AVM in the dominant hemisphere of another patient, in whom an aneurysm had developed over a 2-year period (Fig. 11). The vessel was selectively catheterized (Fig. 12). At the time of IBCA injection, the main trunk of the MCA was occluded (Fig. 13), which resulted in a worsening of the patient’s right-sided weakness that was present previously, and the development of an expressive aphasia. The aphasia cleared completely, and the weakness improved dramatically in the intervening 2
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FIG. 13. Frontal (left) and lateral (right) skull films showing the isobutyl-2-cyanoacrylate (IBCA) cast in the lenticulostriate vessel, and extending into the M₁ segment. Multiple silicone spheres and IBCA are seen in the arteriovenous malformation.

months to function better than before embolization. Two factors accounted for this complication: first, the catheter only reached the ostium of the vessel (Fig. 12), and, second, the increased viscosity of the radiopaque IBCA permitted more inflation of the balloon than the iodinated contrast material, and this displaced the microballoon catheter out of the vessel ostium, causing unwanted MCA occlusion.

Conclusions

Superselective embolization is a promising new technique in the management of otherwise difficult or impossible therapeutic problems. Tolerance to MCA occlusion must be determined prior to embolization because of the high probability of proximal MCA thrombosis during or subsequent to IBCA injection.

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