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While therapeutic endovascular occlusions date from as early as 1904 (1), it is in the last 20 years that major progress has occurred. The development of catheters that permit superselective catheterization and subsequent injection of embolic agents, such as tissue adhesives, represents a remarkable technical improvement (2). For example, in 1960 Luessenhop and Spence reported on the treatment of a cerebral arteriovenous malformation by performing an open arteriotomy of the carotid artery and introducing four large (2.5, 3.0, 4.0, and 4.2 mm) methyl methacrylate emboli that were passively carried by the blood flow to the arteriovenous malformation (3). Today, interventional neuroradiologists perform transfemoral catheterization of branches of the malformation, and precisely inject tissue adhesives that polymerize on contact with blood, causing intravascular thrombosis (4).

The refinement of catheters has progressed from the conventional tapered and nontapered types to single-lumen, double-lumen, flow-guided single-lumen, and detachable balloon catheters. The selection of the appropriate catheter depends on both the size of the feeding arteries and the location of the lesion (5). There has been a similar growth in the development of the different embolization agents. Gelfoam, polyvinyl alcohol foam, silicone spheres, and tissue adhesives such as isobutyl-2-cyanoacrylate and silicone fluid mixtures, have all been used. The decision as to the type of agent injected depends on the flow dynamics and the location of the lesion. Each catheter and each embolization agent has its advantages and disadvantages, its proponents and critics.

Traditionally, intracranial aneurysms have been treated by direct surgical clipping of the aneurysm neck. In 1974, however, an article appeared in the English neurosurgical literature that has had great implications for the advancement of neurointerventional techniques. The work dated back to 1962, when a Russian neurosurgeon named Fedor Serbinenko developed a nondetachable flow-directed balloon catheter (6). In December 1969, Serbinenko treated a carotid cavernous fistula with a nondetachable silicone balloon, followed 1 year later by a similar treatment, but this time with the preservation of the lumen of the internal carotid artery.

Serbinenko's concept of having a balloon move through tortuous arteries was initiated by his observation in 1959, at a May Day celebration in Moscow's Red Square, of children manipulating

helium-filled balloons through the tether lines (7). Stimulated by this idea, he manufactured silicone and latex balloons in a small laboratory. Serbinenko's first paper on his research was published in the Russian literature in 1971 (8). The first English-language article on his experience with balloon catheterization and occlusion of major cerebral vessels was reported in the *Journal of Neurosurgery* in 1974. The balloons were 0.5, 0.7, 1.2 and 1.5 mm in diameter. After being filled with contrast material, the balloons were directed into the desired vessels, aided by television monitoring. Anterior cerebral artery catheterization was obtained using two balloons, with one balloon occluding the main stem of the middle cerebral artery. Both single-lumen and double-lumen balloons were developed; the latter permitted selective angiography either distal or proximal to the occluded segment (a forerunner of the calibrated-leak balloon).

In his 1974 article, Serbinenko first described the use of his balloon system for the investigation of collateral flow through the circle of Willis, and the effects of temporary occlusions of the feeding vessels to arteriovenous malformations. Posterior cerebral artery occlusions were also carried out. In addition, he suggested the treatment of cerebral aneurysms by using two balloons, one distal and the other proximal to the orifice of the aneurysm, and the injection of coagulating substances through the proximal double-lumen catheter. Two deaths occurred in 304 cases of temporary artery occlusions. The first successful external carotid angiogram, performed with the assistance of temporary occlusion of the internal carotid artery, was obtained in February 1964.

Permanent occlusion of cervical and intracranial arteries was accomplished through the use of a non-endhole balloon, which, after being floated to the desired artery, was severed by the cutting edge of the arterial introduction needle (initially Serbinenko obtained carotid and vertebral arteriograms through the direct puncture method). Subsequently, Serbinenko developed an ingenious valve mechanism that allowed balloon detachment from the delivery microcatheter by placing traction on the catheter. Two deaths were reported in 162 cases of permanent arterial occlusions, both following basilar artery catheterization. Buried in his article is the comment, "Cavities of arterial aneurysms may also be occluded by balloons (Figs 19 and 20)." Figure 19 depicts the balloon occlusion of an an-

eurysm at the tip of the basilar artery; Figure 20 depicts the balloon occlusion of a giant aneurysm at the origin of the posterior communicating artery. These two cases herald the current treatment for excluding a saccular aneurysm from the circulation by using detachable coils.

While the achievements of Dr. Serbinenko make his 1974 paper worthy of being included in this series, it would be amiss not to acknowledge other individuals whose pioneer work have made interventional neuroradiology the remarkable success it is today. At almost the same time that Serbinenko was developing his detachable balloon, other researchers were working and experimenting along the same lines. In September 1975 Debrun and co-workers published an article on the use of inflatable, detached balloons in dogs, followed by the treatment of vertebral artery fistulas in humans (9). Soon, the techniques were applied to the treatment of carotico-cavernous fistulae as well as the occlusion of aneurysmal lumens.

Because of the Cold War, Serbinenko may have been less than forthcoming in providing information to some of his visitors from America, who came to his laboratory inquiring about the method of manufacture of his balloons. Nevertheless, many of these visitors were privileged to witness his manual skills in releasing the balloons. Most of his studies were obtained after direct carotid punctures, and the radiologic apparatus he used (although television was used for fluoroscopy) was primitive by European and American standards. Furthermore, because of the lack of interchange that occurred at many levels of science and medicine, many of the original contributions of our Russian colleagues were not adequately shared with the western world (10). Dr. Serbinenko's achievements have made

him world famous, with honorary memberships in several international and national societies. He is an honorary member of the American Society of Neuroradiology. In 1986 he became a member-correspondent of the Academy of Medical Sciences, and in 1995 he became an academician. He is the vice director of scientific affairs for the N. N. Burdenko Neurosurgical Institute, and a member of the editorial board of *Voprosy Neurochirurgii*. Professor Serbinenko is the author of more than 150 papers, and holds 11 patents for medical devices in Russia, the United States, Germany, Sweden, Canada, Japan, and France (7).

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