Superselective Injection of Polyvinyl Alcohol Microemboli for the Treatment of Cerebral Arteriovenous Malformations

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Treatment of cerebral arteriovenous malformations (AVMs) with isobutyl-2 cyanoacrylate (IBCA) injected through a calibrated-leak balloon is a well established procedure. Technical problems, selection of patients, indications, contraindications, and complications have been reported and discussed extensively [1-10]. This technique, though effective, has several risks such as injection of glue into the venous side of the AVM, proximal occlusion of the feeding artery, and gluing of the balloon catheter within the vessels.

Particulate embolic agents such as Silastic spheres have also been used, but the injection is not selective and the results are not as effective as with glue [11-13]. Polyvinyl alcohol (PVA) microemboli are usually used to treat dural malformations or malformations of the face and neck [14]. Recent experimental work in animals has shown the histopathologic changes of intraarterial injection of PVA microemboli in rat cerebral cortex [15]. The results of these experiments using particles of small size (50-150 μm in diameter) indicate that the emboli adhered to the vessel walls and were covered by endothelium by 5-7 days after injection. Between 7 days and 9 months no further changes were seen either in the vessel walls or in the PVA fragments. There was no evidence of any inflammatory response to the PVA in the absence of occlusion. The arterial wall remained free of acute or chronic inflammatory cells for the entire period of the study, its only response being that of endothelial overgrowth. Instead of using IBCA in two recent patients with cerebral AVMs, we superselectively injected PVA microemboli directly into the feeding pedicles close to the nidus of the lesion using silastic microcatheters.

Technique

Silastic tubing 2.5 French in caliber, with an internal diameter of 0.5 mm and an outer diameter of 0.95 mm (Ingenor Medical Systems, Paris), and no. 17 latex balloons (Ingenor Medical Systems, Paris) were used. The latex balloon was glued to the tip of the catheter by using a drop of plasma and IBCA. A hole in the balloon was made with a surgical blade, cutting a very limited part of the distal tip of the balloon. The resulting hole was larger than the one usually made when injection of isobutyl is planned.

The balloon was introduced with a coaxial technique within a 5.8 French Elecath catheter placed within a 6 French Cordis introducer in the femoral artery. The balloon was propelled into one of the feeding pedicles of the AVM using a pressure injection chamber (Becton-Dickinson, Rutherford, NJ). Even after rapid and strong injections the balloon never inflated, but its round and smooth form helped the Silastic tubing to pass the narrow curves of the siphon or branches of the middle cerebral artery, when pressure was exerted within the chamber.

PVA foam particles of 149-250 or 250-590 μm (Unipoint Labs., High Point, NC) were prepared in a distilled water sterile solution after emulsifying the dry powder with distilled water in a blender for about 1 half hour [16]. The solution was then filtered and the wet powder was placed in a test tube with fresh distilled water, steam sterilized, and stored.

When the sterile solution was to be used, the distilled water was decanted; about 1 g of the wet bloc of particles was suspended in 50 ml of nonionic contrast medium (Iopamidol 300, Bracco Industria Chimica, Milan) and repeatedly aspirated and ejected from a 20 ml syringe through a one-way plastic stopcock during progressive tightening of the stopcock. When a homogeneous suspension of particles was obtained, 50 ml of saline and 20 ml of albumin were added.

The PVA particles usually precipitated but no agglutination occurred, and thus a homogeneous solution of suspended particles was obtained. This solution could be injected through the Silastic tubing provided the solution was dilute, permitting the passage of particles up to 590 μm.

To obtain a continuous delivery of separate particles, we used a 20 cm connecting tube between the syringe and the catheter. The catheter was connected to the tube by a 20 gauge plastic needle introduced into its proximal end for about 1 cm. Particles were injected using 1 ml insulin syringes; the
concentration depended on the volume of particles that was aspirated each time from the bottom of the solution into the syringe. We have used this technique in two patients, injecting a total of seven pedicles: three lenticulostriate and four cortical branches.

Case Reports
Case 1
A 29-year-old man had a severe cerebral hemorrhage followed by prolonged coma and right hemiparesis 10 years before. He recovered
but remained hemiparetic. The hemiparesis worsened slightly in the last few years. The AVM (figs. 1A and 1B) was situated in the frontotemporal region involving the basal ganglia and was fed by cortical and deep branches of the middle cerebral, anterior, and posterior cerebral arteries. The patient was treated in three stages, and six different pedicles were injected, always with PVA particles of 149-250 μm. In the first stage two sylvian branches were injected; in the second stage three pedicles were injected: a frontal branch and two lenticulostriate arteries. The frontal branch was the same one injected in the first stage. The catheter became obstructed once and had to be replaced. Rupture of the proximal end close to the connecting needle occurred twice. The broken segments were cut with a blade and the needle reinserted allowing the continuation of the procedure. In the third stage five pedicles were injected, three lenticulostriate and two cortical branches. One of the lenticulostriate arteries and one of the cortical branches had been treated in the previous sessions. The catheter became obstructed once and had to be replaced. Rupture of the proximal end occurred twice.

Figures 1C and 1D show one of the pedicles before and after injection of PVA particles. Before injection an early draining vein was seen, while after injection of PVA there was no more arteriovenous shunting, and many tiny branches became evident. This was never seen after embolization with IBCA, since the occlusion of vessels is more massive. The particles were usually injected in relatively large amounts, using the delivery technique described. Injection of a pedicle was terminated when it was believed, by fluoroscopic and angiographic control, that the part of the AVM supplied by it was occluded.

Discussion

Our experience demonstrates that selective injection of PVA particles through a calibrated-leak balloon directly into the feeding pedicles of cerebral AVMs very close to the nidus

Fig. 2.—Case 2. Lateral (A) and anteroposterior (B) right internal carotid angiograms. Large, deep temporoparietooccipital AVM. C, Selective injection of cortical branch of sylvian artery before embolization with PVA particles. Contrast material is diluted because of high flow. D, After embolization. Many tiny cortical branches are opacified.

Case 2

A 14-year-old boy had an extensive deep right temporoparietooccipital AVM fed by branches of the middle and posterior cerebral arteries (figs. 2A and 2B). He had been having headaches and had a left homonymous hemianopia. He was treated in four stages, three times injecting IBCA and once injecting PVA particles of 149–250 μm. Particles were injected in a sylvian branch. Figures 2C and 2D show the superselective injection of the pedicle before and after embolization with PVA particles. The high flow diluted the contrast material before embolization, while after injection of particles more branches were seen because of occlusion of the part of AVM fed by that pedicle. The patient tolerated the procedure well.

Figures 2E–2G are CT scans obtained after different stages of embolization. The amount of hyperdense PVA particles within the malformation is seen to increase progressively. No side effects occurred, and the patient tolerated the procedure well.
is technically possible and can be effective in occluding the compartment of the AVM fed by the embolized pedicle. On the basis of our experience, however, we believe this technique is not as effective in occluding the malformation as is IBCA. However, it is safer and can be applied to more pedicles in the same session. In fact, a catheter can be reused to embolize different pedicles in the same session since it does not remain occluded by glue. The angiographic result may be different from that obtained after embolization with IBCA. Using PVA particles, the nidus is occluded, but the embolized pedicle may remain patent over a longer segment, and tiny cortical branches not seen before embolization can become visible. More experience is needed to evaluate long-term clinical and angiographic results and to identify the ideal group of patients for this type of treatment.

REFERENCES