Experimental Use of Intraluminal Plastics in the Treatment of Carotid Aneurysms

Preliminary Report

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The following is a report on the results of attempting to treat carotid aneurysms by implantation of intraluminal plastics. The impetus for this project came from the distressingly high mortality reported on patients treated by conventional techniques.1,5,10-13

It occurred to us that much of the difficulty of aneurysmal surgery was caused by: a) hemorrhage encountered during dissection of the neck of the aneurysm, and b) embarrassment of adjacent circulation during the actual treatment of the aneurysm, for example during the clipping, with subsequent spasm and thrombosis of the parent vessel. We thought that by approaching the lesion from a distance, perhaps for example through the lumen of the parent vessel, the above difficulties might be avoided. With this technique, complete dissection of the neck of the aneurysm would not be necessary, the dome would not have to be touched and small but important penetrating vessels near the base of the aneurysm could be preserved during the dissection.

The insertion of plastic into the aneurysm through its neck seemed a feasible method of accomplishing this end (Fig. 1).

Methods

Recent reports on production of artificial aneurysms9,14 were disappointing, and we continued to search the literature until we came upon an excellent method of producing aneurysms in vivo, namely that of German and Black.3 These same authors have also reported important data concerning the dynamics of flow of aneurysms, invaluable to those seeking to produce arterial aneurysms in the laboratory animal.1

Employing the method of German and Black and without the help of anticoagulants, we produced 10 such aneurysms and obtained a rate of patency of 100 per cent.

Dogs weighing approximately 55 lbs. were used. Intravenous Nembutal was used for anesthesia and the airway was safeguarded with an endotracheal tube. After stripping the animal in the supine position, the anterior cervical area was shaved, prepared with pHisolHex and iodine, and sterile drapes were applied. A 4-in. incision along the carotid sheath was made and the more superficial common jugular vein was isolated for a distance of 2 in. This section of vein was then removed, washed in normal saline and a 1-cm. segment was cut off. One end of this segment was closed with a running suture of 5-0 silk employing swaged-on needles. The dissection was then carried down to the carotid artery where a 2-in. segment of this vessel was cleaned of adventitious tissue and each end of the cleaned vessel was surrounded with a double loop of umbilical tape.

Next, a V-shaped opening in the artery was made with arterial scissors. The diameter of the “V” was made as close as possible to one-third of the vessel’s circumference and the point of the “V” was directed toward the heart. The venous sac was then sutured to the site of the arteriotomy using the same suture and material. Immediately during the suturing of the sac to the artery, small bull-dog clamps were applied proximal and distal to the site of the arteriotomy and blood within the vessel was washed out with normal saline. After the venous sac was sutured onto the artery the clamp away from the heart was removed first and any small oozing from the venous sac was controlled with pressure or an additional stitch of 5-0 silk. The clamp proximal to the heart was then removed and any further hemostasis necessary controlled in the same way.

Methyl-methacrylate was chosen as the first plastic to be used because of its ready availability as a cranioplastic material. Later, a small quantity of Aneurynoplast† was obtained. First efforts involved a 21-gauge spinal needle, but we were

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unable to make the plastic flow through a needle of such small caliber. For this reason, an 18-gauge needle was substituted with some measure of success. It was found that methyl-methacrylate in the liquid state had exactly the viscosity required but was very difficult to inject through a small needle. Aneurysmoplast, on the other hand, passed through the needle but did not have the viscosity required for the experiment.

The needle was bent 45 degrees, 2 mm. from its tip, and again 45 degrees, 1 cm. away from its tip. By inserting the needle into the carotid artery one-half of 1 cm. away from the neck of the aneurysm, the needle could be threaded through the lumen of the artery, through the neck of the aneurysm and into the aneurysm itself (Fig. 1-A). A small syringe containing 1 cc. of freshly mixed plastic in liquid form was attached to the needle just prior to insertion of the needle into the artery. Once the tip of the needle was in the aneurysm, the plastic was inserted into the lumen of the aneurysm and the needle was withdrawn. Bleeding from the site of the arterial puncture was controlled with pressure, a small patch of muscle or a tiny figure-of-eight stitch (Fig. 1-B).

The wound was then irrigated with saline and closed in layers using an inverted subcuticular stitch for the skin to prevent the dog from scratching out the sutures.

Arteriography was performed in vivo by inserting an 18-gauge Rochester needle into the carotid artery proximal to the aneurysm and injecting 4 cc. of 60 per cent Renografin during roentgen-ray exposure. Films were obtained in this fashion before and after application of the plastic merely by leaving the plastic tube of the Rochester needle in place during the procedure.

The dogs were sacrificed and the segments of carotid artery bearing the aneurysms were removed at the end of a 2-week period. The aneurysms were photographed in vivo and after removal. Arteriography of the excised segments was then done by tying off one end of the artery and inserting the contrast material into the other end of the artery via a small plastic tube. The aneurysms were then fixed in formalin solution for 2 days at the end of which time they were opened and the aneurysm and artery were examined for patency and adequacy of obliteration of the aneurysm sac by the plastic. Photographs were taken again at this stage following which the tissues were sectioned and stained with hema-toxylin and eosin. Sections were made for comparison of control and plasticized aneurysms in order to determine the reaction of the tissue to the plastic.

Results

A total of 10 aneurysms was produced. Fig. 2 shows a typical aneurysm in vivo. We found it possible to produce 2 such aneurysms on one carotid artery and still maintain patency of both aneurysms and artery. The aneurysms resembled small spheres and had an average outside diameter of 1 cm. Fig. 3 shows one aneurysm opened longitudinally after fixation. A rather striking change in size of the aneurysms occurred as a result of shrinkage during fixation.

Two such aneurysms were used as controls and were not plasticized. The remaining aneurysms were all treated with methyl-methacrylate except two, which were obliterated with Aneurysmoplast.

In order to supplement the information gained by arteriography in vivo the resected specimens were again subjected to contrast studies. Fig. 4 shows a roentgenogram of a control aneurysm made in such a fashion. Again this roentgenogram is somewhat misleading because the aneurysms had a tendency to shrink as soon as they were separated from the pressure-head normally pres-

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**PLASTIC TREATED ANEURYSM**

1A

1B

**Fig. 1.** Insertion of plastic into the aneurysm through its neck.

**Fig. 2.** Aneurysm of jugular sac in vivo.
ent in the carotid artery. Thus the aneurysm in the picture is somewhat smaller than it was when in actual continuity with the arterial circulation. The small defects seen in the lumen of the arteries are caused by air bubbles in the contrast material.

Fig. 5 shows a longitudinal microscopic section of a control aneurysm from a dog sacrificed 2 weeks after operation. The patency of the venous sac used to construct the aneurysm is demonstrated. Fig. 6 shows two aneurysms which were treated with intraluminal plastic. The portion of plastic in contact with the lumen of the vessel acts as a lock because of its collar-button shape. No infringement upon the lumen of the vessel is noted, however.

Fig. 7 is a photograph of a contrast study upon an artery in which two aneurysms were treated with intraluminal plastic.

Fig. 8 is a microscopic section of an aneurysm which had been treated with intraluminal plastic and then removed from the animal 2 weeks postoperatively. (The plastic was removed before sectioning.) Although too early to be really significant we found no evidence of the violent reaction of tissue to plastic as reported by Kline and Hayes. These investigators, however, were using a different plastic (methyl 2-cyanoacrylate) and embedding it in nervous tissue and not in the lumen of blood vessels.

**Discussion**

Although on the surface this technique appears promising, the results so far presented give a misleading impression. Our laboratory trials show that much more basic development both in technique and materials used is necessary before full evaluation can be attempted.

The main difficulty encountered was a technical one, namely the jamming of the syringe by the plastic during the injection. The use of calcium stearate as an inner coating on the syringes and needles resulted in only slight easing of this difficulty. The barrels of the syringes would still “freeze” but not as often. A successful obliteration of the
aneurysm on the first try was obtained in only half the experiments. This difficulty will probably be solved only by development of different plastic which combines both the qualities of high viscosity when in the semiliquid form and ability to flow through a small-bore needle. It should be mentioned that in no instance was embolization a problem.

Combining the feasibility of intraluminal plastic in aneurysms with the recently reported technique of Luessenhop and Velasquez, it would appear to be possible that a
technique might be worked out whereby after inserting a catheter in the carotid artery in the neck and threading it up to the aneurysm, plastic could then be inserted into the aneurysm without craniotomy. The obvious dangers of hemorrhage during this maneuver would have to be evaluated through laboratory experimentation.

This technique might also be applied in cases of deep midline arteriovenous malformations which because of their situation were considered inoperable. We wondered about the possibility of obliterating these lesions by the injection of liquid plastic through the main arterial feeders. To test this theory we injected several small arteries in the spleens of dogs with methyl-methacrylate and with Aneurysmoplast. Fig. 9 shows a typical result. On the lower left is a small segmental artery which is rigid as a result of the plastic in the lumen. Several smaller branches on the upper left are also occluded. (Dissection revealed that the plastic traveled down the vessels only 2 mm. or more in diameter.) Above the white cottonoid are several veins draining in the area. These are soft and no plastic has penetrated through the capillary or sinusoidal bed.

Again, much work needs to be done if any-thing is to be made of this as a useful treatment, but our impression at the present is that intraluminal plastic may, at some time in the future, be safely applicable to deep midline arteriovenous malformations as well as intracranial aneurysms.

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References