Arteriotomy Patching by Means of Intraluminal Pressure Sealing Venous Autografts*

A Preliminary Technical Report

THOR M. SUNDT, M.D., JOHN D. NOFZINGER, M.D., AND FRANCIS MURPHEY, M.D.

Division of Neurosurgery, University of Tennessee, College of Medicine, Memphis, Tennessee

In the course of experimenting with various methods of repairing intracranial aneurysms a technique was developed for the rapid closure of arteriotomy defects in vessels ranging from 2.5 mm. to 4 mm. in diameter. This technique is based upon a concept of intraluminal pressure sealing of a venous autograft held in place by a plastic prosthesis. The results of a pilot project study using this technique are presented in this report.

Materials and Methods

1. Construction of the Prosthesis

A multi-perforated elastic siliconized cylinder is incised by cutting parallel to its long axis, and opened to form a flat sheet (Fig. 1). The corners are held fast by small hemostats to keep the elastic sheet flat (Fig. 2). A piece of autogenous vein is then laid on this surface with its endothelium facing upwards. The vein is secured to the silicone sheet by a running 7-0 nylon circumferential stitch (Fig. 3). The hemostats are removed and the elastic sheet assumes its original cylindrical shape, carrying with it the venous endothelial lining.

The prosthesis is so constructed that its intraluminal diameter is approximately 0.5 mm. to 0.75 mm. smaller than the external diameter of the artery to which it is to be applied.

2. Arteriotomy

Defects in the carotid and femoral arteries of mongrel dogs are made by cutting out wedges of the vessel wall, 0.5 cm. in length and from one fourth to one third of the circumference of the artery in width (Fig. 4).

3. Placement of the Prosthesis

The arteriotomy is then covered by placing the venous-lined prosthesis over the artery and approximating its edges snugly with a running 7-0 nylon suture (Fig. 5). When constructed correctly the prosthesis can be slipped up and down the artery with ease. The sutured approximated edges of the prosthesis are then placed opposite the arterial defect so that an uninterrupted endothelial surface covers the defect.

If the prosthesis is correctly constructed and applied at the time that the circulation is restored, there is no bleeding around the graft. However, if the prosthesis

Received for publication November 18, 1964.

* Supported by the United States Public Health Service Grant No. NB-05651.
Arteriotomy Patching by Venous Autografts

Results

Thirty-one grafts were placed in the carotid and femoral arteries of 13 adult mongrel dogs. The grafts were serially removed, 3 on the 3rd, 12 on the 7th, 6 on the 21st, and 10 on the 31st postoperative days. The grafts were evaluated by means of arteriography and serial histological sections for:

1. Patency
2. Percentage of luminal compromise
3. The rate of re-endothelialization
4. Fibrosis and scar formation surrounding the prosthesis
5. False aneurysmal formation

Of the 31 grafts 28 were patent when the wounds were reopened, a 90.3 per cent overall patency rate. The 3 grafts that were occluded were the first 3 operated in this present series, and all thrombosed within the first 7 days. Two were grossly infected and the 3rd was occluded due to an excessively compromised lumen from a kinked prosthesis. The degree of luminal compensation was determined by arteriography after removing the artery with the associated graft from the animal. It was found that there was a direct correlation between the intraluminal compensation produced by the graft and the degree of compression of the artery from the prosthesis. It was found that if the prosthesis was snugly applied to the artery so that, as noted above, its intraluminal diameter was approximately 0.3 mm. to 0.75 mm. smaller than the external diameter of the artery, very minimal physiological luminal compensation developed. It was also noted that in those arteries in which the intraluminal diameter had been compensated by the prosthesis and graft, as the age of the graft-prosthesis increased this degree of stenosis from the graft decreased.

Endothelium bridging across platelets laid down over the graft surface was noted to be well advanced by the end of the 3rd day. No re-endothelialization was noted at the end of the 1st day; however, the lining of the graft by platelets and protein material was noted. Re-endothelialization was complete in all specimens by the end of the 7th day. There was no evidence of endothelium surviving from the venous autograft itself, but proliferating from the marginal edges of the artery over the graft.

The siliconized plastic tubing incited no foreign body reaction if there was no concomitant infection in the wound. The degree of fibrosis and scar tissue formation was exceedingly small in those wounds that were sterile.

It is realized that the study of false aneurysmal formation and also calcification of grafts requires a scrutiny of arteries subjected to longer survival than 31 days. In this study only one graft showed evidence of false aneurysmal formation. This consisted of a dissection by an endothelial-lined space continuous with the lumen of the artery between the graft and the arterial adventitia. This dilatation was limited to the center of the graft and did not reach the edges.

Discussion

This paper is a preliminary report on a pilot project, evaluating various means of repairing
In the walls of intracranial arteries such as might result from surgical arteriotomy for embolectomy and from the tearing off of aneurysms from the parent vessel.

Techniques directed toward arteriotomy repair on intracranial vessels must be so designed that they do not compromise the arterial luminal diameter, must take into consideration the disease in the adjacent intact arterial wall, and, without the protection of hypothermia, be rapidly applied, often without adequate operative exposure.

Reports in the recent literature outline methods for small vessel arteriotomy repair, as well as for segmental arterial replacement with autogenous, homogenous and synthetic grafts. These methods usually involve suturing under direct or microscopic vision, repair with pressure sensitive plastics such as methyl-2-cyanoacrolate (Eastman 910), electrocoaptive union, etc. In regard to arteriotomy repair, most of the experimental work has been directed toward closure of linear longitudinal incisions and not arterial wall segmental defects. Also, these techniques employ methods that leave some type of foreign body, whether sutures or adhesive plastic, exposed to the parent endothelium and blood stream.

The method reported herein utilizes the vector forces of the arterial pressure to seal the parent arterial wall adjacent to a segmental defect against a venous autograft held in place by a plastic prosthesis (Fig. 6). No foreign body which may act as a nidus for thrombus formation is presented to the blood stream or endothelium other than the autogenous vein graft itself. The plastic prosthesis prevents aneurysmal dilatation of the autografts and it is felt that it can be made long enough to surround the diseased arterial segment adjacent to the arterial defect in aneurysmal disease. Results from this pilot study have been encouraging as to the ease of application, the percentage of patency and the histological repair of the arterial defect incorporating the venous autograft.

At the present time a metallic clip is being manufactured to which the graft can be attached. This metallic prosthesis can be applied in much the same manner as a Raney clip is applied to the scalp. This will eliminate suture approximation of the edges of the prosthesis and facilitate rapid application.

Addendum

Since this paper was submitted for publication, a Mayfield intracranial aneurysmal clip has been modified to form a tube (when closed) for application of the plastic prosthesis and vein graft. This eliminates the necessity of approximating the edges of the prosthesis by suture.

References