Repair of Small Arteries with Contact Cement and Teflon Graft*

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Repair and replacement of vessels, particularly those of small caliber, have presented a difficult problem in surgery.

It is recorded that in 1759 Hallowell, an English surgeon, sutured an artery in man for the first time in medical history. Some years later, in 1772, Asman experimentally sutured femoral arteries in 4 dogs. However, it was not until the latter part of 1800 that rather extensive work and animal experimentation in vascular surgery was begun. In 1889 Jassinowsky published the results of his experiments on the carotid arteries of dogs, horses and calves and stated that the arterial wounds could be sutured with preservation of their lumen.

The technical difficulties and unsatisfactory results of suturing divided vessels prompted Robert Abbe in 1894 to use artificial tubes for end-to-end anastomosis. He devised a small hourglass-shaped tube made of thin glass to join the two ends of the divided femoral artery in a dog. Three years later a small ivory prosthesis was introduced by Nitze for intima-to-intima anastomosis of a divided vessel. In 1900 Payr used absorbable magnesium prosthesis and subsequently Jensen from Copenhagen applied bone prosthesis for anastomosing a divided vessel.

Carrel and Carrel and Guthrie obtained remarkable results in vascular surgery in the early 1900s which started their auto-, homo-, hetero- and finally organ-transplantation experiments on laboratory animals. Their method was a meticulous technique of suturing using silk. Although this technique was accepted by most surgeons, some investigators continued the search for an easier and more satisfactory method of vascular anastomosis. In 1904 Brewer used an adhesive plaster for repair of wounded femoral arteries in dogs. The results were discouraging. Carrel in 1912 studied various prostheses for vascular replacement. He utilized glass, aluminum and gold-plated aluminum tubes in dogs. Tuffier in 1917 introduced a paraffined silver tube for temporary re-establishment of the circulation in a divided artery. Neuhof in 1918 used fascia to patch partial defects of the carotid artery, femoral artery and abdominal aorta in dogs.

By 1920 surgeons interested in vascular surgery were quite aware of the possibility of reconstructing blood vessels and preserving their patency. They had developed techniques for end-to-end, end-to-side and side-to-side anastomosis. They had studied auto-, homo- and hetero-transplantations; they had devised various prostheses and even adhesive techniques, but none of these was quite satisfactory, especially when small vessels were involved.

Following World War I, despite the discouraging results in vascular repair of battle casualties, vascular surgery did not receive very much attention. The 1920s and early 1930s were rather quiet years regarding progress in vascular surgery. However, in the latter part of the 1930s surgeons started experimenting on blood vessels. To some extent the results of these experiments served to improve the techniques for arterial repair used during World War II. In 1938 Kabat described a new method of arterial anastomosis for acute experiments by using an eversion frame. Isenberger and Carrol in 1939 used muscle flaps for repair of arterial defects. Murray and Janes in 1940 bridged divided arteries in dogs by glass cannulas.

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and kept then patent for 76 hours with the use of heparin.

Blakemore et al. in 1942 introduced a technique which received considerable attention and was used clinically during World War II. This was a nonsuture method of bridging arterial defects using Vitallium tubes and vein grafts.

Since 1955 vascular repair and replacement, particularly surgery of small arteries, have stimulated the interest of many surgeons and investigators. Numerous forms of prostheses made of various synthetic materials for nonsuturing technique have been introduced; different types of grafts, artificial or autologous, homologous or heterologous, have been used; adhesive, stapling and finally microscopic suturing have been tried (Table 1). Some of these methods give rather good results in large arteries (external diameter more than 4 mm.) but the outcome in the small arteries is not as encouraging. The poor results are caused mainly by thrombosis, aneurysmal dilatation, hemorrhage or necrosis of the arterial wall (and present authors).

### TABLE 1

**Various methods of repair and replacement of arterial defect in small arteries**

<table>
<thead>
<tr>
<th>Method</th>
<th>Material</th>
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<tr>
<td>I. Repair of a cut</td>
<td>A) Suturing technique: Suture, Silk, nylon, Dacron, Dermalon, Nylons, Dermafilament, Nitinol, Suture plus patch, Rubber, vein, fascia, muscle flap, knitted Dacron. B) Nonsuturing technique: Adhesive plaster of Brewer, AD/hera (methyl cyanoacrylate), Eastman 910 (methyl cyanoacrylate), flexible adhesive, Contact Cement (present authors), Adhesive and patch, Mersilene, Nylon, autogenous artery, autogenous vein, autogenous fascia, Dacron, Teflon (and present authors).</td>
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<tr>
<td>II. Repair of a divided artery</td>
<td>A) Suturing technique: Suture (including suture plus adherent synthetic resins and microsurgery). B) Nonsuturing techniques, which may be divided into the following 3 groups:</td>
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