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Replacement of Small Veins by Autologous Grafts: Application of an Endothelium-Preserving Technique

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Introduction

Grafting of veins for arterial replacement has proven itself to be a useful method in reconstructive vascular surgery. Replacement of veins, however, has proved to be difficult and with few exceptions the post-operative patency rate as a rule is unsatisfactory (as evidenced by a review of Haimovici).[7] In previous studies conducted by this department,[4] it has been shown that much of the endothelium is damaged during dissection of veins unless a "no touch technique" is employed. After venous grafting into arterial blood vessels, the endothelium preserved by this no touch technique remains in place and retains its venous pattern for at least 70 days.[2, 3]

The preservation of venous endothelium is not critical when arterial segments are being replaced. Arterial segments remain patent after endarterectomy and after replacement with synthetic grafts. The situation is different for venous surgery. Most surgeons, because of a relatively high rate of thromboses after replacement of venous segments, create an arteriovenous fistula distal to the reconstructed segment in order to arterialize the circulation and to prevent post-operative thromboses. This procedure was advocated first by Kunlin[9] and by Aschberg and Hindmarsh.[1]

Previous investigations[2, 3, 6] have shown that jugular veins of dogs can be replaced experimentally with a 100% patency rate, provided that the endothelium-preserving technique for dissection and anastomosis of veins is used. In 10 jugular vein autografts in dogs, neither an early nor a late obstruction was observed for periods up to 1 year.

The following investigations deal with the transplantation of minor veins

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in rabbits. These investigations were stimulated by the frequent necessity to graft minor veins during replantation of limbs or fingers or in order to facilitate free tissue grafts in plastic surgery.

Materials and Methods

No Touch Dissection. The superficial neck veins of rabbits (anterior and posterior facial vein and jugular vein) were dissected by the following method. After performing a median skin incision, the vessels were exposed by lateral retraction of the skin and by sharp dissection of the SC tissue. Using micro-instruments, the vessels then were dissected, but at no time was a vessel touched by any instruments, sponges, or the surgeon's hand. Only muscle and connective tissue came into contact with the forceps and were disconnected with fine scissors. The branches of the vessels were coagulated by a bipolar coagulator with care being taken not to damage the venous wall. When bleeding occurred, the vessels were irrigated with saline containing small amounts of heparin, and the irrigating fluid was aspirated in a place remote from the vessels.

The Endothelium-preserving Technique in Anastomoses. The endothelium-preserving technique for anastomosing major veins consists briefly in the avoidance of any shrinking at the ends and agglutination of the lumina of the vessel after division and in avoidance of any contact of the anastomosed area with the surgeon's instruments. During the procedure of anastomoses, each end to be anastomosed is kept extended and patent by holding sutures. In addition, the dissected grafts are kept extended by their fixation to a frame. It can be shown histologically that the mechanical irritation caused by the search for the lumina of the vessels results in severe endothelial damage. A detailed description of the minor vessel anastomosis follows.

After dissection, the medial branch of the external jugular vein (vena facialis anterior) was doubly ligated. The posterior facial vein was ligated cranially, and at this end a needle was introduced into the vein, and the vein was flushed free of blood by saline (Figure 1A). Then the posterior facial vein and the external jugular vein were clamped by two small clamps fixed to a frame (Figure 1B) so that any shrinkage of the graft could be avoided. The left veins were dissected but not divided until the graft was fixed to them by holding sutures. This prevented shrinking of the host vein. The dissection was carried out under loupe magnification (×3, 5); however, the anastomotic procedure was carried out under the operating microscope (×10).

Instead of clamping the host vein, the veins were excluded from the circulation by transfixation sutures only. After ligation and division of the

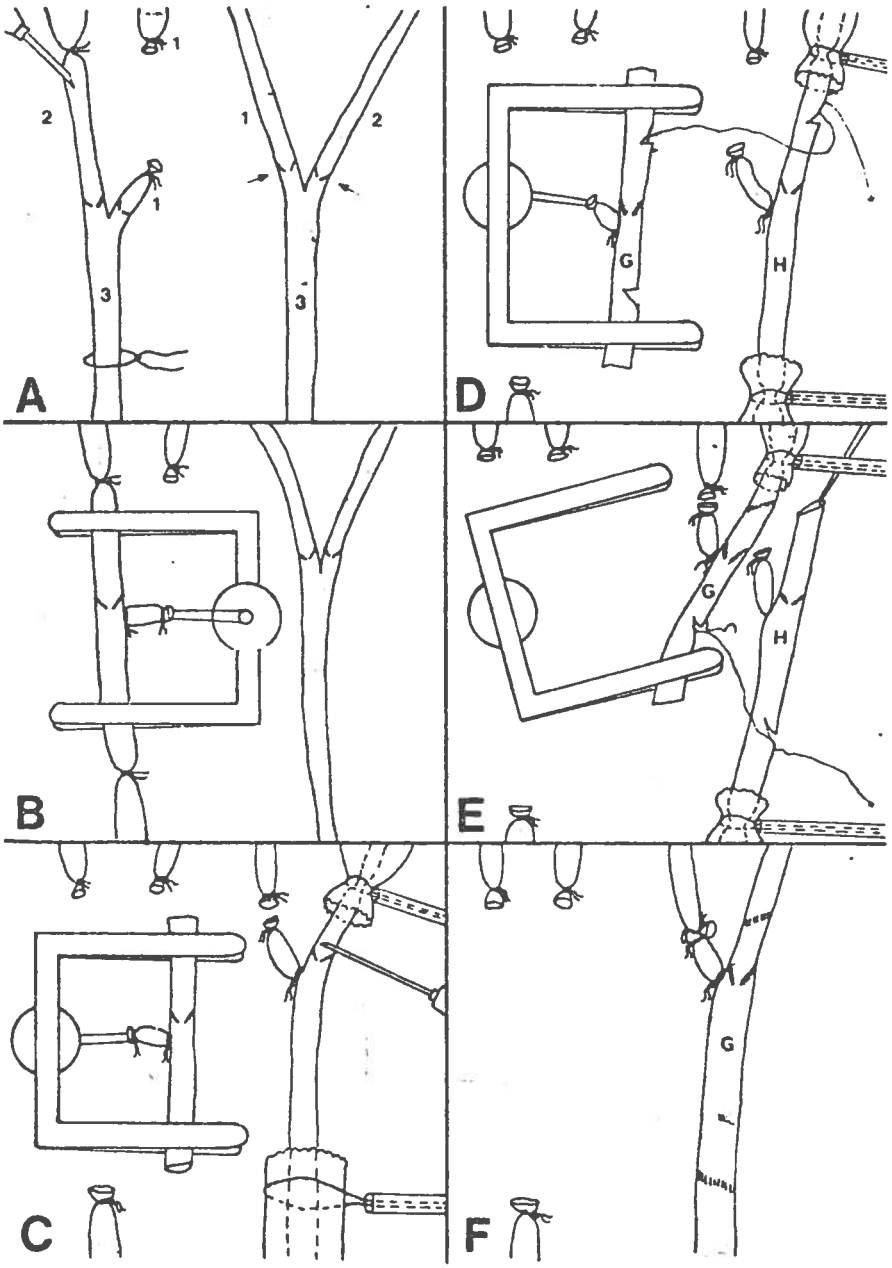

FIG. 1. Transplantation of jugular veins of rabbits. A, The veins are dissected. The anterior facial vein (1) is ligated; the posterior facial (2) and the external jugular veins (3) are flushed. Arrows, site of regular venous valves. B, the posterior facial and the external jugular veins of the right side are clamped and kept in extension by a special device. The ligated anterior facial vein is fixed to the frame in order to prevent torsion. C, the veins of the right side are severed. The veins of the right side are temporarily occluded by transfixation ligatures, and the right anterior facial vein is ligated; however, a short stump is preserved. The host veins are flushed. D, the graft (G) and the host veins (H) are opened by oblique incisions. The cranial ends of the vessels are fixed by a holding stitch. E, the cranial anastomosis is sutured. The graft is kept under tension by the frame, and the host vein is kept under tension by a holding stitch. F, the distal anastomosis is sutured, and the hemostatic transfixation sutures are removed. The stumps of the anterior facial veins are tied together in order to prevent torsion of the graft.

Results

Silver-stained Endothelia. When conventional transplantations were performed using a careful technique but not the no touch technique and not the endothelium-preserving technique of anastomosing the vessels, great parts of the endothelium were destroyed. In most instances, this made up more than 70% of the intimal surface. Close to the anastomoses, the vessels were devoid of any endothelial lining up to 10 mm on both sides of the anastomotic line, totaling an area of 4 cm of length for both anastomoses (Figure 2).

When the endothelium-preserving technique was applied for dissection and for anastomosis, most of the graft showed an intact endothelial lining (Figure 3). Close to the anastomoses, the area of endothelial damage was reduced to 1–2 mm on both sides of the anastomotic line (Figure 4). Therefore, we may say that the endothelium-preserving technique reduced the endothelial damage in the area of the anastomoses from 40 to 8 mm. In some instances, a normal endothelium was found directly adjacent to the stitching canal.

Patency of the Grafts. Of 10 grafted veins, 9 appeared to be patent during the first angiography 2–4 days after the operation. In 1 animal, a swelling of the neck was observed 2 days after the operation. In this animal, angiography was performed and the lumen was found to be obliterated. After opening the wound, a great amount of pus could be evacuated. Of the

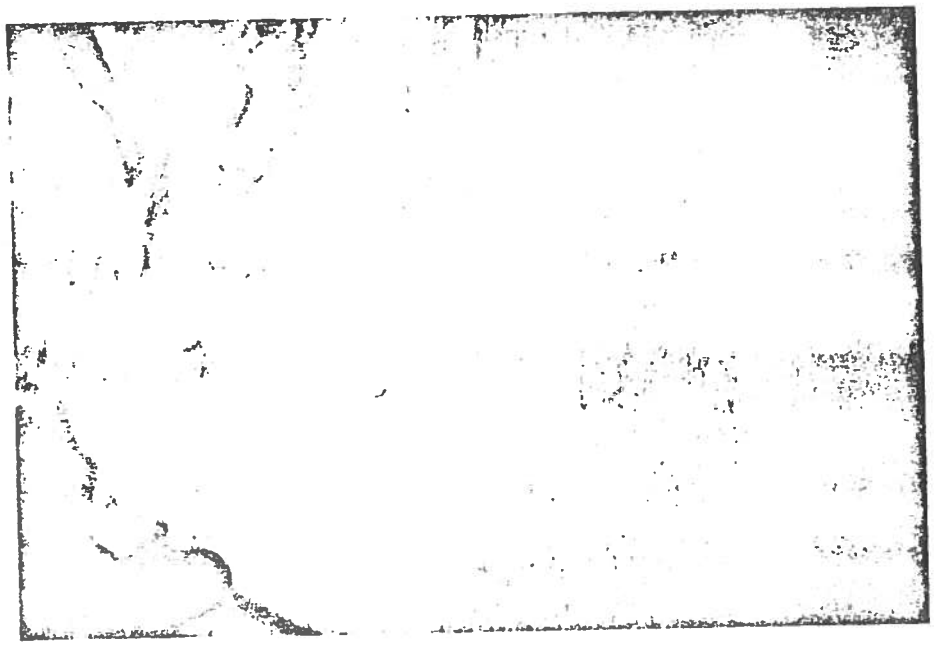

FIG. 2. Anastomosis, sutured conventionally, silver stained. Note absence of endothelial cells adjacent to the suture line (left). Specimen immediately after finishing the anastomosis. ×50.

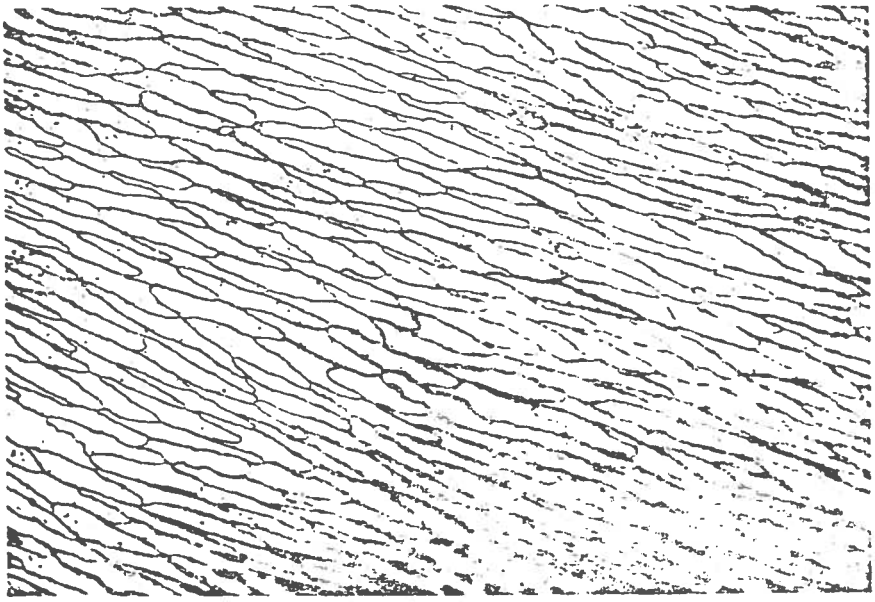

FIG. 3. Unchanged silver line pattern after no touch dissection. ×100.

FIG. 4. Anastomosis after application of an endothelium-preserving suture method. Note endothelial cells close to the suture line. ×100.

remaining 9 animals with grafts at the first angiography, all grafts were found to be patent at the time of the second angiography 3–6 months after the operation (Figure 5). After the second angiography, the animals were sacrificed and the veins were excised for histologic examination. All veins proved to be patent at autopsy. The intima was smooth and shining, and the veins differed from normal veins only by a thickening of the adventitia.

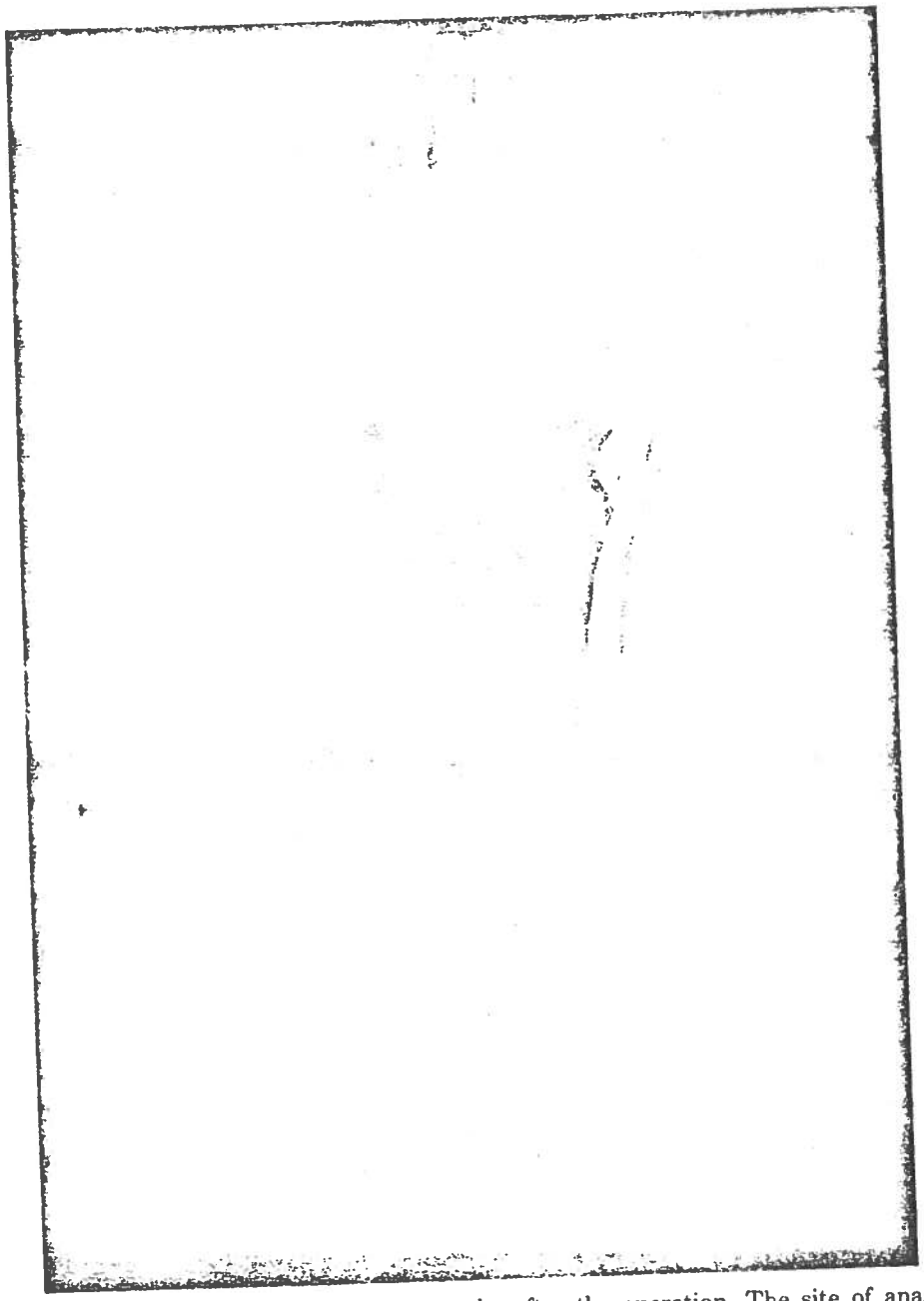

FIG. 5. Veno-venous transplantation 5 months after the operation. The site of anastomoses is indicated by hemostatic clips.

Discussion

Most surgeons create arteriovenous fistulae or anticoagulate post-operatively or use both of these procedures in order to maintain patency of the graft. Because of the endothelium-preserving technique, none of these procedures was necessary to keep the major grafted vessels patent as has been reported elsewhere.[2, 3, 6] Arteriovenous fistulae and post-operative anticoagulation were also unnecessary for the small veins of the rabbit with an

external diameter of 2–3 mm for the posterior facial vein and of 4–5 mm for the external jugular vein. Favorable results for grafting major veins were reported by Jacobson and Katsumura[8] and recently by Oberlin et al. (1980). Both groups of authors report that they use a meticulous technique. Oberlin et al. reported that failures were never due to the length of the graft but rather to technical errors.

The technique of the no touch dissection and the method for an anastomosis preventing the shrinking of the graft and of the severed host veins safeguard the preservation of a normal endothelium. The no touch technique, however, requires great concentration by the surgeon. We therefore often divided the work between 2 surgeons, 1 who performed the vessel removal and the other who performed the anastomotic procedure.

One of the authors currently applies this technique routinely with much success clinically for the replantation of whole limbs and fingers. We feel confident in recommending the endothelium-preserving technique for all veno-venous transplantations.

Summary

In 10 rabbits, the right posterior facial vein together with a segment of the external jugular vein was grafted to the veins of the contralateral side. In spite of the small size of the grafted veins, 9 veins proved patent when angiographic controls were performed 2–4 days after the operation as well as 3–6 months thereafter. In one case, a purulent wound infection coincided with an early obliteration of the graft. No post-operative anticoagulation was carried out. The feasibility of grafting small veins successfully was attributed to the endothelium-preserving technique applied for dissecting and anastomosing the grafted veins.

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anterior facial vein, the posterior facial vein was temporarily ligated cranially, and the external jugular vein was temporarily ligated caudally. For these ligatures, the veins were transfixed by 2-0 sutures which did not contact the veins themselves and which left sufficient amounts of muscular and connective tissue around the veins so that they would not be damaged when the ligatures were tied. In order to tie the ligatures, the threads were pulled through thin plastic tubes and clamped at the ends (Figure 1C). For anastomosing the vessels, any contact with instruments was avoided. In order to show the lumen and to keep the anterior and posterior walls of the vessel apart, the ends of the cut vessels were irrigated by saline with a syringe and a thin needle. This floating of the edges enabled the surgeon to apply the holding sutures (Figure 1D).

The graft was anastomosed in such a way that the parts which were damaged by the clamps could be discarded (Figure 1E). Oblique incisions were made, and the anastomoses were sutured with interrupted sutures with 10-0 monofilament nylon. It is essential to avoid any torsion of the vessels. Therefore, before removing the graft, the ligated anterior facial vein was fixed to the frame holding the clamps. Before grafting, the frame was rotated for 180° without reversing flow direction. After anastomosing the posterior facial vein and the external jugular vein again, the stump of the anterior facial vein of the graft was fixed to the stump of the anterior facial vein of the host side (Figure 1F). If this step was omitted, this branch of the jugular vein tended to turn to the other side so that the blood flow was inhibited in the twisted vein.

Histologic Examinations. In order to check the integrity of the endothelial lining immediately after performing the anastomosis, some vessels were excised, mounted on cork plates, cut open, and irrigated with 5% glucose solution. Thereafter, the vessels were stained for 29 seconds in 0.25% silver nitrate solution. After a second rinsing with glucose solution, the vessels were fixed in 10% formalin, dehydrated in alcohol solutions of increasing concentrations, and cleared in wintergreen oil. Then the vessels were mounted between slide and coverglass. Intact areas of the intima were covered by a system of silver lines running predominantly in the longitudinal axis of the vessel. In places of endothelial damage, transverse silver lines were seen in relation to the media of the vessels.

Angiography. In order to check the patency of the grafted vessels, a first angiography was performed 2–4 days after the operation. A second angiography was performed 3–6 months after the operation. For angiography, the contrast medium (30% Angiografin) was injected into a vein of the left ear. The early angiographies were carried out in order to exclude possible early thromboses that might be recanalized at a later stage.