Hemodynamics of In Situ Vein Bypass: the Role of Side Branch Fistulae

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Ten patients undergoing femoral-popliteal and femoral-tibial in situ saphenous vein bypass for limb salvage were studied to determine the effects of side branch arteriovenous fistulae on flow through the distal end of the graft into the outflow artery. Studies were performed intraoperatively with electromagnetic flow probes. Following completion of proximal and distal anastomoses, flow was established through the graft and measured through its proximal and distal ends. Side branches were then ligated, and flow through the distal end of the graft measured again. Papaverine was administered and flow measured once more. Measured flows were consistent with those observed in previous studies, as were changes in flow induced by papaverine. Results indicate statistically significant diversion of blood through the fistulae, and a statistically significant increase in distal graft flow accompanying ligation of side branch fistulae. These data support the practice of routine side branch ligation during in situ bypass grafting. (Ann Vasc Surg, 1986, 1, 335-339).

KEY-WORDS: In situ vein bypass. — Arteriovenous fistula. — Hemodynamics.

Infrainguinal reconstruction with in situ saphenous vein was reported as early as 1962 by Hall [1] and in 1965 by May, DeWeese and Rob [2]. It has become well accepted in the treatment of peripheral vascular ischemia, particularly since the work of Leather et al. [3, 4] in developing technology permitting the safe incision of saphenous vein valve cusps. Reported patency is at least equal to that achieved by reversed vein techniques, and utilization of the saphenous vein seems to be enhanced.

Techniques for performance of in situ bypass have been well established and are now somewhat standardized through the efforts of Leather [5] and others. Some controversies persist, however. For example, Cartier has a series of over 600 such bypasses performed in Montreal with results comparable to those of other authors (Personal communication, 1985). His technique differs in that he does not recommend ligation of saphenous vein side branches, preferring to permit them to remain as arteriovenous fistulae. Ligation of these fistulous branches is recommended by most other authors.
The role of these fistulae in graft patency is likely to be a reflection of their effect on graft flow. The fistulae might be expected to increase the flow into the proximal end of the graft by lowering total resistance to graft flow. However part of the blood flow in the graft is likely to be "stolen" by the low resistance outflow through the fistulae. The difficulty in resolving the net effect of side branch fistulae on graft flow is akin to the controversy over the role of distal arteriovenous fistula in maintaining patency of distal bypass as advocated by Dardik [6].

In order to better understand these relationships, we undertook a study to measure the effect of side branch fistulae on flow through in situ bypass grafts to the popliteal and infrapopliteal arteries.

**PATIENTS AND METHODS**

Ten unselected men, all veterans, undergoing in situ bypass to the femoral and tibial arteries were studied. All were smokers, four were hypertensive, and three were medicated for diabetes. All grafts were performed for limb salvage. Nine patients suffered rest pain and four presented with significant skin envelope injuries.

Standard in situ bypass graft technique was modified slightly, in that side branches of the saphenous vein identified during dissection were encircled, but not ligated — except as needed to permit valve incision. Valvulotomy was performed so as to injure as few side branches as possible, most often one to three. Proximal and distal anastomoses were completed and flow established through the graft.

At this point, a Statham SP-2201 electromagnetic blood flowmeter with a probe of appropriate diameter was placed on the proximal end of the graft and flow into the graft measured. The probe was then placed on the distal end of the graft and flow into the outflow vessel measured. These figures were compared to give an estimate of the amount of "steal" through the fistulous side branches.

All identified side branches were then ligated. Flow measurements were repeated at the distal end of the graft and compared to the flow prior to fistula ligation. Sixty milligrams of papaverine was then administered through a 20 gauge angiogram catheter in the proximal end of the graft, and flow measurement at the distal end of the graft repeated once more after five minutes. Studies were performed over as brief a time period as possible, usually about fifteen minutes.

Completion angiography was performed after all flow studies were finished to permit ligation of any side branches overlooked during dissection. Studies were not repeated after angiography to avoid artifactual changes which might result from induction of vasomotor changes by the dye.

Ankle-brachial pressure indices were measured preoperatively and in the early postoperative period. Statistical analysis of flow changes and changes in ankle-brachial index was performed utilizing the paired Student's test allowing each patient to act as his own control.

**RESULTS**

A summary of results is presented in Table 1. Four patients underwent femoropopliteal bypass while six required femorotibial bypass. Ankle-brachial index increased in every patient. Mean preoperative ankle brachial index was 0.27 ± 0.07. Mean postoperative ankle brachial index was 0.80 ± 0.03. This difference is statistically significant at the p < .0005 level. This demonstrates that successful bypass was achieved in this group of patients.

Flow at the proximal end of the graft with open side branches averaged 345 ± 65 cc/min (mean ± standard error of the mean). Flow at the distal end of the graft averaged 69 ± 18 cc/min. This difference is statistically significant at the p = .001 level. Thus, an average of 80 % of the blood entering the graft was siphoned into the low resistance arteriovenous fistulae prior to ligation of saphenous side branches.

Flow at the distal end of the graft increased to a mean of 118 ± 21 cc/min following ligation of the fistulae identified at vein dissection. This represents a mean 71 % increase in flow resulting from ligature in flow ligation. The difference between preligation and postligation flow through the distal end of the graft is statistically significant at the p < .01 level.

Flow through the distal end of the graft increased further five minutes following administration of papaverine, reaching a mean of 168 ± 23 cc/min, an average increase of 42 %. This change is also significant at the p < .005 level.

These changes are reflected in Figures 1 and 2.

**DISCUSSION**

Several authors have measured flow in infrainguinal bypass grafts, including Barner [7], Bernhard [8], Mundth [9], and Terry [10]. These reports indicate the clinical utility of flow measurements, which can be used to predict graft patency. More recently Bush [11] has reported that in situ grafts have higher rates of flow (by electromagnetic determination) in the operating room than those reported for reversed grafts. Mean flow of 161 ± 31 cc/min was reported by that study. This value increased to 267 ± 48 cc/min following papaverine administration, a 66 % increase. The comparable values in the current study were 118 ± 65 cc/min prior to papaverine and...