Late Failure of Reversed Vein Bypass Grafts

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Late failure of reversed vein bypass grafts is preceded by the appearance of stenotic lesions, which progress to total occlusion. These lesions appear either as intrinsic graft lesions or as new arteriosclerotic lesions in contiguous arteries. The present study summarizes the University of Pennsylvania experience with these lesions in 521 vein grafts inserted from 1979 to 1985. The grafts were grouped according to the site of the distal anastomosis; 231 above-knee popliteal (FP AK), 171 below-knee popliteal (FP BK), and 119 tibial (FT). The overall incidence of stenotic lesions was essentially identical with the three grafts (21%), but the relative incidence of intrinsic graft to arterial lesions was higher with the more distal grafts. The most common graft lesions developed adjacent to the proximal anastomosis, which is the narrowest part of a reversed vein graft. The popliteal artery was the most common site of outflow stenosis. There was negligible incidence of tibial lesions. The most common inflow arterial lesion was located in the common femoral and iliac arteries. The superficial femoral artery (SFA) was a rare site of inflow stenosis, even though it was at risk because 96 grafts originated from the SFA or popliteal artery. Sixty-seven per cent of the graft and 52% of the arterial lesions were treated successfully by percutaneous transluminal angioplasty; the rest had minor surgical revisions. This resulted in a 19%, 10%, and 9% improvement in 5-year patency for the FT, FP BK, and FP AK bypasses. These results justify an aggressive policy of graft surveillance to identify and treat stenotic graft lesions before graft occlusion.

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LATE FAILURE OF reversed venous bypass grafts is often preceded by the appearance of stenotic lesions within the graft or contiguous arteries. Detection and treatment of these lesions averts graft occlusion and improves long-term graft patency.

The present study summarizes the results of surgery in 521 reversed vein grafts (*in situ* grafts have specifically been excluded from analysis) in which aggressive follow-up has uncovered a 21% incidence of potentially treatable graft and arterial lesions in above-knee popliteal (FP AK), below-knee popliteal (FP BK), and tibial (FT) grafts. The study emphasizes the importance of early detection of stenotic lesions before graft occlusion to achieve superior long-term graft patency.

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Materials and Methods

All infrainguinal reversed vein bypass grafts (521 in all) performed at the Hospital of the University of Pennsylvania between 1979 and 1985 were analyzed retrospectively. The grafts were grouped according to the site of distal anastomosis: 231 FP AK, 171 FP BK, and 119 FT. Forty-four per cent of operations were performed because of threatened limb loss based on symptoms of rest pain or the presence of ischemic lesions (Table 1). The incidence of limb salvage operations varied between grafts and ranged from 79% for FT to 28% for FP AK. Diabetics accounted for 38% (200 of 521 patients) of grafts overall and diabetes was present in 50% of FT grafts (Table 1).

Follow-up examinations included documentation of ischemic symptoms, if any, palpation of peripheral and/or graft pulses, and noninvasive studies, all performed at the time of discharge and at 3-month intervals during the first 18 to 24 months. After 24 months follow-up examinations occurred at 6-month intervals. Vascular laboratory measurements included measurement of segmental arterial pressures and pulse volume recordings (PVR). If the ankle brachial index (ABI) decreased ≥ 0.2 or the PVR amplitude decreased ≥ 5 mm, a presumptive diagnosis of graft failure was made and an arteriogram was ordered, even if the patient was asymptomatic and had satisfactory pulses. The importance of vascular laboratory testing for detection of graft lesions and the parameters used to diagnose the failing graft have been published.[1-4]

TABLE 1. *Indications for Surgery and Incidence of Diabetes by Graft Type*

Grafts	FP-AK 231		FP-BK 171		FT 119		Total 521	
Claudication	166	72%	102	60%	25	21%	293	56%
Limb Salvage	65	28%	69	40%	94	79%	228	44%
Diabetes	78	34%	62	36%	60	50%	200	38%

TABLE 2. *Reversed Vein Bypass Grafts: Location and Incidence of Stenotic Lesions by Graft Type*

Grafts No.	FP-AK 231		FP-BK 171		FT 119		Total 521	
Inflow artery	15	6%	10	6%	4	3%	29	5%
Outflow artery	14	6%	5	3%	0	0%	19	4%
Graft conduit	18	8%	21	12%	22	18%	61	12%
Total stenotic grafts	47	20%	36	21%	26	21%	109	21%

When the arteriogram revealed stenotic lesions in the graft or contiguous arteries, percutaneous transluminal angioplasty (PTA) was the first treatment choice. We have published details of this technique with respect to vein graft lesions.[5] Alternative surgical methods of treatment include vein patch angioplasty, short bypass grafts around proximal stenotic lesions, and short extension grafts to bypass distal lesions.[6-8]

Life-table patency was calculated according to the guidelines of the Ad Hoc Committee on Reporting Standards for the Society of Vascular Surgery and the International Society of Cardiovascular Surgery.[9] Cumulative patency reported herein includes grafts in which patency was maintained by treating stenotic lesions before graft occlusion. It has been suggested that this be referred to as assisted primary patency[10] to differentiate it from secondary patency, which includes reopened occluded grafts. Primary patencies were also calculated, in which any occlusion or reintervention, no matter how minor, was considered an endpoint for graft patency. Treatment of new inflow or outflow arterial lesions beyond the graft and its two anastomoses did not represent an endpoint with respect to primary patency by these criteria.

Results

Twenty-one per cent (109 of 521 grafts) of grafted limbs developed a stenotic lesion diagnosed on follow-up examination and confirmed by arteriography (Table 2). In 12% (61 of 521 grafts) of bypasses, lesions were localized to the vein graft and in 9% (48 of 521 grafts), lesions were in contiguous inflow or outflow arteries. Although each graft had essentially equal incidences of stenoses, the distribution of these lesions by graft type revealed a progressively higher incidence of graft lesions and lower incidence of arterial lesions with the more distal grafts. As shown in Table 3 the relative percentages of graft/arterial lesions varies from 38 to 62 for FP AK, 58 to 42 FP BK, to 85 to 15 FT. The most common graft lesion was found near the proximal anastomosis and accounted for 56% (34 of 61 graft lesions) of total graft lesions. The proximal anastomosis represents the smallest end of a reversed vein graft and, therefore, it is not surprising that the relative incidence of proximal graft stenosis was highest with the FT grafts.

Outflow arterial lesions developed in 4% (19 of 521 bypasses) of grafted limbs. The incidence was 6% (14 of 231 bypasses) in FP AK, 3% (5 of 171 bypasses) in FP BK, and 0% (0 of 119 patients) in FT grafts. The popliteal artery, rather than the more distal vessels, was the predominant site of disease. Some of these lesions developed close to the distal anastomosis and may have been caused by clamp trauma. Others developed at sites distant from the anastomosis and clearly represented progression of atherosclerotic disease.

Inflow arterial lesions appeared in 5% (29 of 521 bypasses) of grafted limbs, predominantly in common femoral or iliac arteries. The superficial femoral artery (SFA) was a rare site of an inflow stenosis, even though 18% (96 of 521 grafts) of grafts were at risk because the proximal anastomosis was located distal to the common femoral artery. Even in the FT grafts, where 39% (46 of 119 grafts) of proximal anastomoses arose from the superficial femoral or popliteal artery, only a single SFA stenosis occurred. This data reinforces the suitability of the more distal SFA or popliteal artery as a proximal site for graft insertion.[11]

The interval from surgery to the appearance of stenotic lesions is shown in Figure 1. The number of arterial and graft lesions are indicated separately at each interval along with the incidence of stenosis, based on the number of grafts at risk at the beginning of each interval. In addition the cumulative stenosis is calculated based on the total number of stenotic grafts (109) observed during the 10 years of follow-up. The majority (61%) of lesions appeared by 1 year. The peak incidence of graft lesions occurred during the first 6 postoperative months, while the arterial lesions peaked 6 months later. Twenty-four per cent (126 of 521 grafts) of grafts occluded during 10 years of follow-up and 60% of these occlusions appeared by 1 year, par-

TABLE 3. *Reversed Vein Bypass Grafts: Distribution of Stenotic Lesions by Graft Type*

	FP-AK		FP-BK		FT		Total	
Arterial	29	62%	15	42%	4	15%	48	44%
Graft	18	38%	21	58%	22	85%	61	56%
Total stenotic grafts	47		36		26		109	

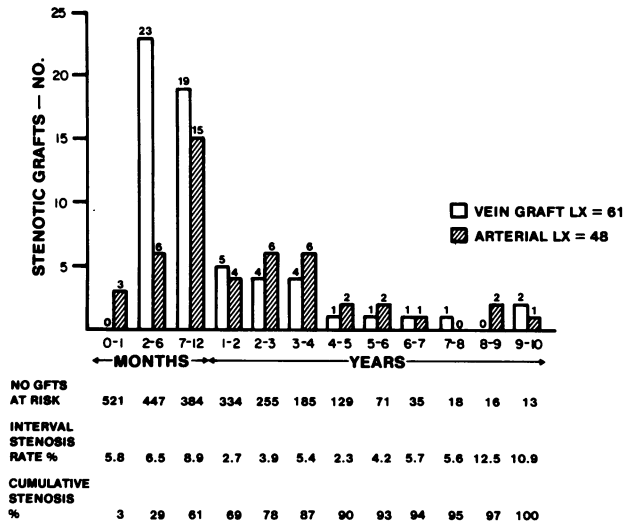

FIG. 1. Appearance time of the stenotic graft conduit and contiguous arterial lesions. Interval stenosis is the percentage of stenosis, based on grafts at risk for each interval. Cumulative stenosis is the percentage of total stenoses observed during 10 years of follow-up (109), which have appeared by each interval.

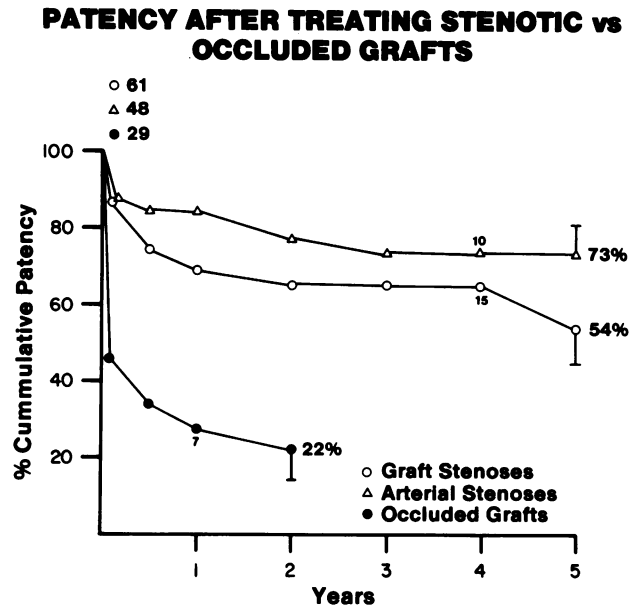

FIG. 3. Cumulative patency achieved after treating stenotic vein grafts, new arterial stenoses, and occluded grafts.

alleling the 1-year incidence of stenotic grafts. (Fig. 2). The major difference was in the early postoperative interval (0 to 1 month) in which 25% of the occlusions, but only 3% of stenoses, occurred.

PTA was the preferred method of treating graft and arterial lesions and was the initial treatment in 89% (54 of 61 graft lesions) of graft lesions and 60% (29 of 48 arterial lesions) of arterial lesions. Thirty- three per cent (18 of 54 graft lesions) of graft and 17% (5 of 29 arterial lesions) of arterial lesions recurred at least once after PTA. Some recurrent lesions were redilated a second and third time, but ultimately most were corrected surgically. Notwithstanding this, overall, 67% (41 of 61 graft lesions) of graft lesions and 52% (25 of 48 arterial lesions) of arterial lesions were treated by PTA alone.

The 5-year cumulative graft patency after the treatment of stenoses was 73% for arterial and 54% for graft lesions (Fig. 3). The treatment of 29 occluded grafts, using thrombectomy and/or thrombolytic therapy, resulted in a meager 22% 2-year patency, emphasizing the importance of diagnosing stenotic lesions before graft occlusion.

Cumulative and primary patencies are shown in Table 4 and Figure 4. The difference between cumulative and primary patency represents the improved graft patency achieved by treating failing grafts and forestalling graft

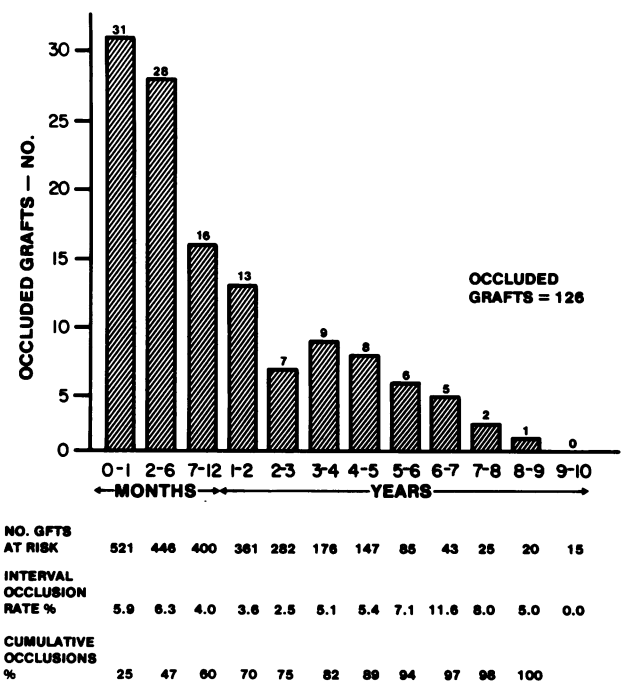

FIG. 2. Appearance time of occluded grafts. Interval occlusion rate is the percentage of occlusions, based on grafts at risk for each interval. Cumulative occlusions are the percentage of total occlusion observed during 10 years of follow-up (126), which have appeared by each interval.

TABLE 4. *Five-Year Cumulative Patency by Graft Type and Surgical Indication*

	FP-AK (%)	FP-BK (%)	FT (%)
Claudication			
Patency	81*	75	62* (NS)
Primary patency	73	61	48
Salvage			
Patency	68	52*	72* ($p < 0.05$)
Primary patency	51	44	56

* Groups compared for significance of difference.

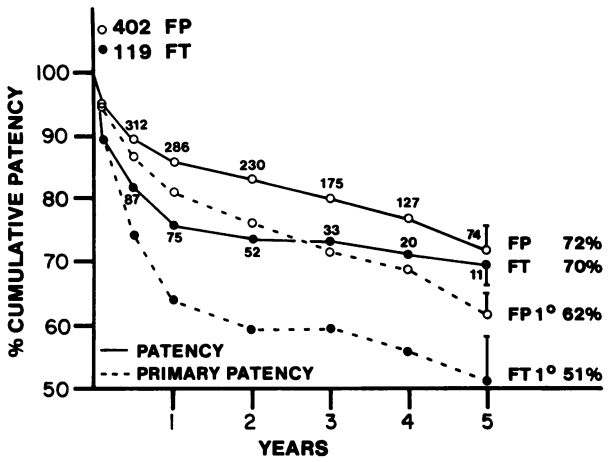

FIG. 4. Cumulative patency of FP and FT vein grafts. These patencies include grafts, in which stenoses, but not occlusions, have been corrected to maintain patency. Primary patencies consider stenoses and occlusions as endpoints for graft patency.

occlusion. The overall improvement in 5-year patency was 10% for FP and 19% for FT grafts (Fig. 4). This relationship held true even when graft patency was analyzed according to indications for surgery (Table 4). An unexpected result was the superior patency of FT grafts done for salvage, especially when compared to the FP BK grafts ($p < 0.05$).

Discussion

Since the classic article on vein graft lesions by Szilagyi,[12] several studies have documented the problem of vein graft and arterial lesions, which are a potential cause of graft failure.[1,2,4,6-8] The present study adds to this data by recording our observations in a large group of venous bypass grafts and emphasizes the relative distribution of graft/arterial lesions as they relate to the most distal level of the grafted artery. Intimal hyperplasia is the major cause of intrinsic graft lesions and is found predominantly near the proximal anastomosis. The higher incidence of this lesion found with tibial grafts suggests an association with the small graft lumen of tibial grafts, compared to FP BK and FP AK grafts. Despite an extensive body of work describing pathologic changes in vein grafts,[13,14] no definitive cause has been identified and no suitable preventative strategies have been developed. In the present series, many, but not all, patients have been treated with antiplatelet drugs, including aspirin and dipyridamole before operation and in the postoperative period. While we believe that this has contributed to lower perioperative graft occlusions, there is no evidence that it has reduced the incidence of vein graft lesions.

Arteriosclerotic disease in adjacent arteries predisposes these vessels to clamp trauma during the performance of bypass surgery. This may account for those lesions seen in juxtaposition to the proximal or distal anastomosis, but does not explain the development of new lesions at a distance from the anastomotic areas.

The present study confirms previous reports that these lesions appear early,[1,4,6] with 61% of stenoses appearing by 1 year and 78% of stenoses appearing by 3 years. Interestingly these cumulative rates of graft stenoses parallel graft occlusions after the initial postoperative period, where technical factors are the predominant cause for graft occlusion.[6,15] This data reinforces the need for frequent follow-up evaluation during the first 1 to 2 postoperative years to detect stenotic lesions before graft occlusion.

Comparison of the patency rate achieved in the present series of bypass grafts with previous reports from our institution in 1978[16,17] indicate that a significant improvement in graft patency has occurred with femoropopliteal bypass grafts. For claudicators the 5-year patency has improved from 68%[16] to 75% and 81%, and for the salvage group from 46%[17] to 52% and 68% (Table 4), depending on whether the distal anastomosis was in the AK or BK popliteal artery. Superior contemporary patency rates have also been reported by others for femoropopliteal grafts.[18-20] Recent reports of femorotibial grafts also show higher patency,[21-24] compared to older reports.[25-27]

While improved technical refinements have certainly produced part of this improvement, we believe that the detection and treatment of stenotic lesions have had a major impact on graft patency in our series. Several other investigators have reported data similiar to our own, with a high incidence of graft lesions detected in the postoperative period,[2,6-8] while others have not. We have no explanation as to why the recent report of Taylor[21] on tibial grafts does not indicate any significant appearance of these late stenotic lesions and we are tantalized by their excellent primary patency rates, despite the fact that the technical details of their operations are similar to our own methods. Perhaps part of the discrepancy may be related to the shorter follow-up period because only 10 of 110 tibial grafts were available for follow-up at 3 years. In contrast to this, however, is the fact that a majority of stenotic lesions should have appeared within this 3-year interval.

Our data also varies somewhat with other reported studies of femoropopliteal grafts in which FP BK bypass grafts have been associated with a higher patency rate than the FP AK grafts.[19,28] This has been attributed to bypassing potential areas of stenosis in the popliteal artery with the BK grafts. While this is a reasonable assumption, the present data do not support it. No significant differences in patency were observed in FP BK *versus* FP AK grafts, regardless of the indication for surgery. However for the limb salvage group, FT patency was significantly better than FP BK, which suggests that the tibial vessels are the preferred site of distal anastomosis when operating for limb salvage.

Our data indicate that bypass to more distal vessels is associated with the development of more intrinsic vein graft lesions and fewer new arterial lesions. We have demonstrated that both types of lesions can be corrected by PTA or surgery, but that PTA continues to be our primary method of therapy. Veith[2] has also used PTA as primary treatment for graft lesions, while others[6-8] have preferred to treat these lesions surgically.

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