Lower Extremity Revascularization in Diabetes

Late Observations

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Hypothesis: Despite the success of infrainguinal arterial bypass in diabetic limb and foot salvage, optimism remains guarded because of purported high late mortality and limb loss in patients with diabetes.

Design: Inception cohort, with minimum 5-year follow-up.

Setting: Tertiary referral center.

Patients: Eight hundred forty-three consecutive patients undergoing lower extremity arterial reconstruction from July 1, 1990, through July 31, 1993.

Intervention: Infrainguinal arterial bypass with vein graft.

Main Outcome Measures: Graft patency, limb salvage, and survival.

Results: A total of 962 vein grafts (843 patients) were performed; 795 grafts (82.6%) were performed in patients with diabetes (DM group) and 167 (17.4%) in non-diabetic patients (NDM group). Average age was 68.4 years, and was lower in the DM group (66.2 [range, 27-92 years] vs 70.5 years [range, 37-96 years]) (P = .005). In-hospital 30-day perioperative mortality was 1.4%, lower in the DM group (0.9% vs 4.2%) (P = .005). The target vessel was more frequently infrageniculate in the DM group (87% vs 77%; P = .002). Five-year primary and secondary graft patencies were 74.7% (DM group, 75.6%; NDM group, 71.9%; P = .80) and 76.2% (DM group, 77.0%; NDM group, 73.6%; P = .90), respectively. The 5-year overall limb salvage rate was 87.1%, also unaffected by diabetes (DM group, 87.3%; NDM group, 85.4%; P = .80). Survival at 5 years was 58.1% overall and virtually identical in the DM (58.2%) and NDM groups (58.0%).

Conclusions: Diabetes mellitus does not influence late mortality, graft patency, or limb salvage rates after lower extremity arterial reconstruction. Concern for long-term mortality and limb loss in diabetic patients is unwarranted and should not prevent aggressive attempts at limb salvage.


Awareness of the pathophysiological features of vascular disease in diabetess,1-5 coupled with technical advances in extreme distal arterial reconstruction6,7 and an aggressive approach to diabetic foot problems,8,10 has led to improved limb and foot salvage in patients with diabetes.31 Despite this success, there remains a guarded optimism about long-term function and survival in these patients, particularly toward diabetic patients with peripheral arterial disease. Higher rates of lower extremity amputation12 increased incidence and severity of coronary artery disease,13,14 and higher cardiovascular mortality15 are well-recognized in diabetic patients. The misconception of “diabetic small-vessel disease” has been refuted but still appears in the literature.16 Considered together, these may suggest poorer outcome in treated patients or, even worse, may completely discourage any aggressive treatment in these patients.

Previous studies from our institution have demonstrated successful limb salvage17 and functional outcome18 following distal arterial reconstruction in diabetic patients, with low perioperative morbidity and mortality rates. In an effort to better define the long-term outcome of these patients, we herein present our experience with a cohort of diabetic and non-diabetic patients undergoing lower extremity revascularization, with follow-up of at least 5 years.

RESULTS

A total of 962 vein grafts were performed on 843 patients; 795 grafts (82.6%) were
PATIENTS AND METHODS

Since January 1990, data from every patient undergoing vascular surgery at our institution have been entered prospectively into a computerized vascular registry. We reviewed the data on all consecutive patients who underwent infrainguinal arterial bypass with vein graft at the Deaconess Hospital, Boston, Mass, from July 1, 1990, through July 31, 1993. Patient demographics, associated atherosclerotic risk factors, and indication for operation were entered into the database at the time of surgery. Operative details were recorded by the attending surgeon. Perioperative death and complications were also documented. Follow-up generally consisted of an early postoperative visit (usually at 1 month), then every 3 months for the first year and every 6 to 12 months thereafter. All follow-up visits were recorded into the registry. Graft patency was determined by results of physical and handheld continuous-wave Doppler examinations. Ankle-brachial indices were measured on selected patients during the follow-up visits. Duplex scanning graft surveillance was used in selected cases. Further follow-up was obtained from office records and telephone interviews.

Statistical analysis was performed using a commercially available computer program (Stat View; Abacus Systems, Berkeley, Calif). Primary graft (grafts patent from initial surgery without any subsequent intervention), secondary patency (all grafts remaining patent), limb salvage (all or part of the foot remaining), and survival rates were calculated using the actuarial life table method. Differences were calculated using the log-rank test. Categorical variables were compared using the chi-square test, and continuous variables were compared using the t test. Statistical significance was considered at P<.05.

performed in patients with diabetes (DM group) and 167 (17.4%) in nondiabetic patients (NDM group). Patient demographic data and concomitant cardiovascular risk factors are presented in Table 1. Patients in the DM group were younger at presentation than those in the NDM group, and coexisting coronary artery disease and a history of heart failure were also more common among DM patients. A greater proportion of NDM group patients were active or previous cigarette smokers, and revision bypass grafts were also more common in NDM group patients.

Tissue loss (gangrene or ulcer) was the predominant indication for operation in both groups (Table 2), but was more common among the DM group. In fact, in the DM group, claudication or rest pain was an indication in only 6.5%. Asymptomatic failing grafts were also uncommon among both groups, presenting in only 5.5% of the entire group.

Operative details regarding graft location and type of conduit are presented in Table 3. In-hospital perioperative mortality was 1.4%, and was lower in the DM than in the NDM group (0.9% vs 4.2%; P = .005). Grafts originating from the popliteal artery were more common in the DM group, consistent with the pattern of arterial vascular disease in diabetes. The dorsalis pedis artery was used as the outflow site in nearly one third of DM group patients, again reflecting the differing patterns of disease in both groups. Overall, bypass grafts to the infrapopliteal and inframalleolar arteries were more common among DM group patients (P<.01). A variety of venous conduits and configurations were used in both patient populations (Table 3).

Follow-up continued at least 5 years on all patients. Cumulative 5-year primary graft patency was 74.7% overall, with no difference between groups (DM group, 75.6%; NDM group, 71.9%; P = .80) (Figure 1). The secondary graft patency rate was 76.2% for the entire cohort, and was also similar between groups (DM group, 77.0%; NDM group, 73.6%; P = .90) (Figure 2).

Primary graft patency varied according to outflow site. Five-year patency was 86.1% for grafts placed to the popliteal artery, 76.9% for tibial (anterior and posterior tibial artery) and peroneal grafts, 69.7% for dorsalis pedis grafts, and 56.8% for grafts placed to the tarsal and plantar arteries (P = .003 for popliteal vs dorsalis pedis and tarsal-plantar grafts). The conduit also had a dominant effect on primary patency, with arm vein (AV) grafts having lower patency rates compared with in situ (ISSV), translocated nonreversed (NRSV), and reversed saphenous vein (RSV) grafts. Primary patency rates were 55.4%
for AV, 78.1% for ISSV, and 82.1% for NRSV-RSV grafts ($P = .002$ for AV vs ISSV and NRSV-RSV grafts).

Five-year limb salvage and survival rates were virtually identical in both groups (Figure 3 and Figure 4). The overall limb salvage rate was 87.1% (DM group, 87.3%; NDM group, 85.4%; $P = .80$). Survival at 5 years was 58.1% in the entire cohort (DM group, 58.2%; NDM group, 58.0%; $P = .94$).

### Table 3. Graft Location and Type of Conduit*

<table>
<thead>
<tr>
<th>Groups</th>
<th>DM (n = 795)</th>
<th>NDM (n = 167)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inflow artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Common femoral</td>
<td>409 (51.4)</td>
<td>96 (57.5)</td>
</tr>
<tr>
<td>Superficial femoral or profunda</td>
<td>126 (15.8)</td>
<td>36 (21.6)</td>
</tr>
<tr>
<td>Popliteal</td>
<td>213 (26.8)</td>
<td>20 (12.0)</td>
</tr>
<tr>
<td>Tibial</td>
<td>3 (0.4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Previous graft</td>
<td>44 (5.5)</td>
<td>15 (9.0)</td>
</tr>
<tr>
<td>Outflow artery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above-knee popliteal</td>
<td>79 (9.9)</td>
<td>25 (15.0)</td>
</tr>
<tr>
<td>Below-knee popliteal</td>
<td>108 (13.4)</td>
<td>35 (21.0)</td>
</tr>
<tr>
<td>Tibial</td>
<td>228 (28.7)</td>
<td>54 (32.3)</td>
</tr>
<tr>
<td>Peroneal</td>
<td>83 (10.4)</td>
<td>22 (13.2)</td>
</tr>
<tr>
<td>Dorsalis pedis</td>
<td>243 (30.6)</td>
<td>13 (7.8)</td>
</tr>
<tr>
<td>Plantar or tarsal</td>
<td>28 (3.5)</td>
<td>4 (2.4)</td>
</tr>
<tr>
<td>Previous graft</td>
<td>26 (3.3)</td>
<td>14 (8.4)</td>
</tr>
<tr>
<td>Conduit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In situ saphenous vein</td>
<td>218 (27.4)</td>
<td>30 (18.0)</td>
</tr>
<tr>
<td>Reversed saphenous vein</td>
<td>149 (18.7)</td>
<td>31 (18.6)</td>
</tr>
<tr>
<td>Nonreversed saphenous vein</td>
<td>261 (32.8)</td>
<td>69 (41.3)</td>
</tr>
<tr>
<td>Arm vein</td>
<td>100 (12.6)</td>
<td>18 (10.8)</td>
</tr>
<tr>
<td>Composite</td>
<td>67 (8.4)</td>
<td>19 (11.4)</td>
</tr>
</tbody>
</table>

*DM indicates diabetic; NDM, nondiabetic. Data are given as number (percentage) of grafts. Because of rounding, percentages may not all total 100.

### Figure 1. Cumulative primary patency rates of vein grafts in diabetic (DM group) and nondiabetic patients (NDM group).

### Figure 2. Cumulative secondary patency rates of vein grafts in diabetic (DM group) and nondiabetic patients (NDM group).

### Figure 3. Limb salvage up to 5 years among patients with (DM group) and without diabetes (NDM group).

### Figure 4. Five-year diabetic (DM group) and nondiabetic patient (NDM group) survival rates.

Previous clinical and epidemiological studies have confirmed that diabetes mellitus is a strong risk factor for atherosclerotic coronary,20 cerebrovascular,21 and peripheral vascular disease,22 as well as a higher cardiovascular mortality rate,23 compared with the general population. In addition, the relative risk for lower extremity amputation is 40 times higher among patients with diabetes.24 It may appear, therefore, that long-term prognosis is worse among diabetic patients with overt peripheral vascular disease when compared with their...
nondiabetic counterparts. In our study, however, we have demonstrated long-term bypass graft patency, limb salvage, and survival rates to be comparable between DM and NDM groups with peripheral vascular disease.

Despite a higher incidence of coexisting coronary disease and congestive heart failure, in-hospital mortality was approximately 1% in the DM group. This may result from our recognition of the patterns of cardiac disease in diabetes, specifically, a higher incidence of silent coronary ischemia and a predisposition to congestive heart failure. We therefore have adopted an aggressive approach toward invasive perioperative cardiac monitoring in this population and continue to advocate its use.

The anatomic pattern of vascular disease in diabetics has been well described and is characterized by atherosclerosis of the infrageniculate arteries with relative sparing of the pedal arteries, which has allowed for successful arterial reconstruction to these vessels. Our study confirms this finding. The dorsalis pedis artery was the most common outflow site among the DM group, and short bypass grafts originating from the popliteal artery were also more common among the DM group.

Five-year primary and secondary graft patency rates were similar between groups. In addition, there was virtually no difference between the primary patency rate (74.7%) and the secondary patency rate (76.2%) for all grafts. This likely results from the fact that most grafts did not undergo routine duplex surveillance. Because stenoses in some grafts may not have been detected because of our selective surveillance routine, secondary patency rates might have been higher if routine duplex scanning of all grafts had been performed regularly. However, despite a selective (not routine) surveillance, primary and secondary graft patency rates were comparable to those of other reports. In addition, the 5-year primary patency rate of the dorsalis pedis grafts (69.7%) was virtually identical to the patency rate (68%) previously reported from our institution.

Arm vein grafts had lower patency rates when compared with saphenous vein grafts. This is consistent with previous reports, including the experience reported from our institution. The reasons for this difference are multiple and probably not related to any flaw in the intrinsic biology of arm veins. The arm veins have often received previous venipunctures or cannulations, with resultant injury and scarring. Angioscopy and careful preparation of the conduit can detect and diminish the sequela of these injuries, which probably contribute to acute and delayed graft failure. Despite this lower patency, however, patency rates are superior to those of prosthetic grafts, and we continue to advocate AV grafts as the first alternative to ipsilateral saphenous vein, particularly in diabetic patients. Contralateral saphenous vein has been seldom used in our largely diabetic population for several reasons. In our previous series, we found that contralateral saphenous vein is present in only 38% of the patients who required AV grafts. More important, we and others have found diabetes to be a strong risk factor for subsequent contralateral bypass, approaching 60% at 3 years, and have therefore reserved its use for subsequent need.

Although more than 90% of the DM group presented with tissue loss, limb salvage was 87.3% at 5 years, similar to that achieved in the NDM group. This results from our continued adherence to the fundamentals of diabetic foot management: prompt control of infection and surgical drainage, evaluation for ischemia, prompt arterial reconstruction, and subsequent secondary procedures on the fully vascularized foot. Success with extreme distal arterial reconstruction has enhanced our ability to perform direct foot-sparing surgery, such as metatarsal resections and osteotomies, and has allowed for direct soft tissue coverage or even free-flap procedures in select cases.

Most important, we have found that patients with diabetes and peripheral vascular disease have the same survival rate at 3 years as nondiabetic patients with peripheral vascular disease. Although multiple reports have noted 5-year survival of 30% to 60% among all patients with critical leg ischemia, our study suggests that survival rates after revascularization are identical between both groups. The comparable long-term graft patency, limb salvage, and survival rates all strongly emphasize that patients with diabetes and peripheral vascular disease should expect the same quantity and quality of life as nondiabetic patients with peripheral vascular disease, and the presence of diabetes should never deter aggressive attempts at limb salvage.


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REFERENCES

DISCUSSION

David B. Pilcher, MD, Burlington, Vt: This is a careful analysis of one of the largest bypass series studied, perhaps only surpassed by Leather’s 1853 in situ grafts. In 1971 the group from the Deaconess presented a smaller series, and concluded graft patency rates and symptomatic improvement are similar in diabetic and nondiabetic patients. The same thing we heard today, a much smaller group. They also concluded that the outcome in both the diabetic and the nondiabetic patients was a different animal than just the diabetic patient.

In summary then, I agree that you’ve shown what many others have shown: that diabetes does not influence the graft patency and late mortality compared to nondiabetics who are undergoing vascular bypasses. There is room for improvement in both the diabetic and the nondiabetic patients when the 5-year mortality that you’re talking about is 42%.

Carl E. Brensden, MD, Portland, Me: The results are excellent. Parenthetically, I wish I had a better understanding of the interrelationship of atherosclerosis and diabetes and, for example, why this more peripheral distribution of the occlusive process in the infranigual arteries that characterize it. My specific question, however, is the very difficult group of diabetic patients who are renal dialysis patients and how many of your patients were on dialysis that required limb salvage, reconstruction, or, briefly, what is your approach to those patients, and how aggressive are you in that very difficult group?

Dr Akbari: First, insofar as long-term survival is concerned, it is remarkably similar in the 2 groups. And despite quite a few advances in the treatment of cardiovascular disease, the heart remains as the No. 1 cause of death in these patients. Reports still document anywhere from a 30% to 60% long-term 5-year mortality in patients undergoing lower extremity revascularization. Certainly different than your 42% mortality. What about the patients with renal failure and on hemodialysis? Renal failure patients continue to constitute anywhere from 10% to 15% of our practice. And multiple studies have shown that graft patency rates are not influenced by the presence of renal failure, but long-term survival and wound healing rates are. What do we do with the difficult patient who has a very, very large defect in the foot and is on dialysis? Well, obviously if that patient has no chance for rehabilitation, with no chance for wound healing, then consideration should perhaps be given to an amputation. But more and more, we’re seeing patients with renal failure which includes patients who have previously undergone kidney transplantation. The disease is the same, and if in those patients we’re talking about a small ulcer on the foot, then every effort should be made towards limb salvage.

The real consideration should be given to young patients with diabetes whom we might be looking at with grim eyes and saying their chance for long-term survival is poor. It’s just not the case. Most of these patients have the exact same prognosis as patients without diabetes who need revascularization.