

Fifteen Year Experience with Subcutaneous Bypass Grafts for Lower Extremity Ischemia

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A 15-year experience with 92 subcutaneous arterial bypass grafts for lower extremity revascularization has been reviewed. Fifty-nine AF and 33 FF bypass operations were performed on 89 patients whose average age was 66 years. The overall five-year survival was 33% compared to an expected survival of 80%. 88% of the AF, and 76% of the FF operations were performed for limb salvage, bypass of an aortic aneurysm, or replacement of an infected aortic graft. The remainder were performed for intermittent claudication on patients who were too ill to withstand an intra-abdominal operation. 75% of the patients with AF grafts and 64% of those with FF grafts experienced complete relief of lower extremity ischemia, including all of the patients with claudication. Graft patency was analyzed by the life table method. In the FF series, 74% of the grafts remained patent for one year; 73% for two years; 66% for three years; and 53% for four years. A 50% incidence of thrombosis occurred at the end of two years in the AF group. The patency rate of the AF grafts was also studied with regard to the type of graft material employed: a 50% incidence of thrombosis was reached at 36 months with knitted Dacron; at 18 months with weave-knit Dacron; and at 9 months with woven Dacron.

These data indicate that: (1) contrary to our previous report, weave-grafts provide adequate blood flow to the lower extremities but do not remain patent as long as more conventional types of reconstruction; (2) subcutaneous grafts should be performed only when an intra-abdominal procedure is contraindicated or life expectancy is limited.

EXPERIENCE WITH SUBCUTANEOUS bypass operations at the San Francisco Veterans Administration Hospital has been extensive. We began performing femoral-femoral (FF) grafts in 1960, and continued with the introduction of axillary-femoral (AF) grafts in 1962.² These operations have gradually become part of the standard repertoire of vascular surgeons.

The indications for subcutaneous bypass grafts have

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varied considerably in 15 years. Originally, they were considered for individuals who were unacceptable candidates for an intra-abdominal operation.^{2,11,18} Later, they came to be used in the management of infected abdominal aortic prostheses^{2,4,10,13} and to bypass abdominal aortic aneurysms.³ In some instances, they have even been employed as a substitute for more conventional arterial reconstructions.^{5,16,17} The early results of subcutaneous bypass procedures have generally been quite satisfactory but the long term followup has not been well documented.

The purpose of this report is to analyze the immediate and late results of 92 operations employing subcutaneous arterial bypass grafts.

Clinical Material and Methods of Study

Through 1975, 33 femoral-femoral (FF) and 59 axillary-femoral (AF) bypass operations have been performed on 89 patients. Their records were reviewed and living patients were personally contacted and examined. Only three patients were lost to followup. Data was recorded on punch cards and hand-sorted. Life tables were constructed to assess graft patency and patient survival.^{1,8} Once the continuity of a graft was interrupted, it was classified as thrombosed even if continuity was restored by subsequent graft thrombectomy, revision, or replacement. There were 87 men and two women in the study. The mean age in both the AF and FF groups was 66 years. The distribution of patients by decades is summarized in Table 1.

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TABLE 1. Age Distribution

Age	Femoral-Femoral	Axillary-Femoral
30-39	1	0
40-49	2	4
50-59	7	12
60-69	9	19
70-79	12	22
80-89	2	2
mean	66 Years	66 Years

TABLE 3. Operative Indications

	Femoral-Femoral	Axillary-Femoral
Claudication	8 (24%)	7 (12%)
Rest pain	16 (49%)	18 (31%)
Gangrene	7 (21%)	20 (34%)
Aneurysm bypass	1 (3%)	5 (8%)
Infected aortic graft	1 (3%)	9 (15%)

Most of the patients had serious associated diseases. The incidence of associated illness in the two treatment categories is summarized in Table 2. Cardiac disease, respiratory dysfunction, and cerebrovascular insufficiency were the most frequent problems.

All patients underwent preoperative angiography. From 1960 to 1971 translumbar aortography with additional bilateral percutaneous femoral arteriography was employed. Since 1971, most patients have undergone arteriography by retrograde axillary or femoral artery catheterization utilizing the Seldinger technique. In addition, intra-operative arteriograms were performed on most of the patients at the conclusion of their operation to insure a technically adequate result.

Operative Indications

Subcutaneous grafts were initially employed for revascularization of the lower extremities when a direct aortic reconstruction was deemed inadvisable because of intra-abdominal sepsis or concomitant illness. Early success led to a trial of their use in the management of abdominal aortic aneurysms and intermittent claudication. The operative indications for the patients in this study are summarized in Table 3. The majority of operations were performed for limb salvage: 73% in the FF group and 65% in the AF group.

Operative Technique

Femoral-femoral Bypass

Both groins are entered through longitudinal incisions and the common, superficial, and profunda

TABLE 2. Associated Disease

	Femoral-Femoral (33 patients)	Axillary-Femoral (59 patients)
Hypertension	8 (24%)	24 (41%)
Heart Disease	23 (70%)	45 (76%)
Pulmonary Disease	16 (48%)	36 (61%)
Cerebrovascular Insufficiency	8 (24%)	18 (31%)
Diabetes Mellitus	6 (18%)	11 (19%)
Renal Disease	4 (12%)	14 (24%)
Cardiac and Pulmonary	15 (45%)	31 (53%)

femoris arteries isolated. On the inflow side, a longitudinal arteriotomy is made in the common femoral artery, and an end-to-side anastomosis is performed between the graft and the artery using a continuous suture of 4-0 braided Dacron. The two groin incisions are connected by a subcutaneous, suprapubic tunnel. If there are no stenotic lesions of the superficial femoral or profunda femoris arteries on the outflow side, this anastomosis is made with the common femoral artery. If stenotic lesions are present in either of these arteries, the longitudinal arteriotomy is continued through the stenotic segment and the bevel of the graft fashioned to serve as a patch angioplasty. Alternatively an angioplasty of autogenous material with or without thromboendarterectomy may be employed.

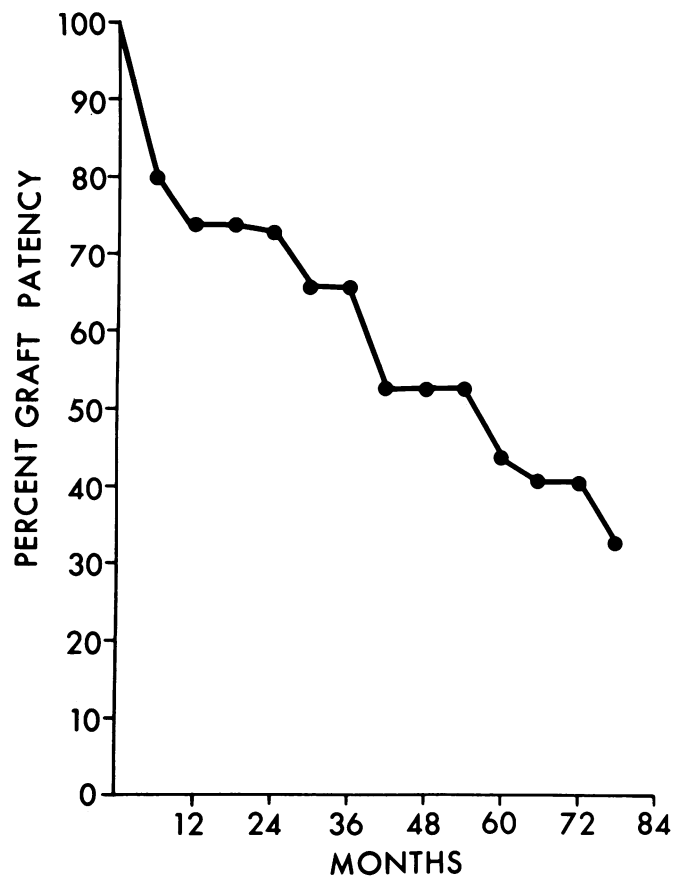


FIG. 1. Patency rate of femoral-femoral bypass grafts determined by life table method (1960-1975).

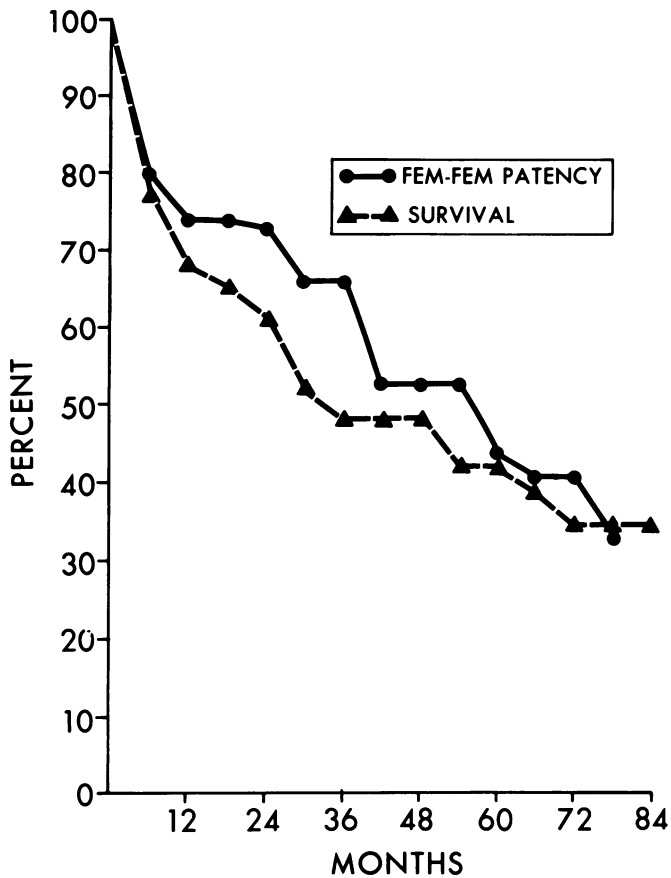


FIG. 2. Comparison of femoral-femoral grafts and patient survival determined by life table method.

Unilateral Axillary Femoral Bypass

The first and second portions of the axillary artery are mobilized via an infraclavicular incision, and the ipsilateral common femoral artery is isolated through a longitudinal groin incision. A tunneling instrument is used to create a subfascial tunnel beneath the pectoralis major and external oblique aponeurosis. An end-to-side anastomosis is performed between the graft and the axillary artery using a continuous 4-0 braided Dacron suture and the graft is passed through the tunnel into the groin incision. If there are stenotic lesions present in the superficial femoral or profunda femoris arteries, a patch angioplasty and/or endarterectomy is performed; otherwise, the graft is anastomosed to the common femoral artery with a continuous 4-0 braided Dacron suture.

Axillary-bilateral Femoral Bypass

A side-arm is attached to the axillary femoral graft in the ipsilateral groin, passed through a suprapubic subcutaneous tunnel, and anastomosed to the contralateral femoral artery as described.

During the period of study, 19 right-to-left FF by-

passes and 14 left-to-right FF bypasses were performed. Twenty grafts were 10 mm diameter; 11 were 8 mm; one was 6 mm; and there was one vein graft. The prosthetic materials employed were: knitted Dacron, 16 grafts; woven Dacron, two grafts; weave-knit Dacron, ten grafts; and Dacron external velour, two grafts.

Thirty-five unilateral axillary femoral bypasses and 24 axillary-bilateral femoral procedures were performed. Thirty-nine were 10 mm grafts, and 20 were 8 mm grafts. The prosthetic materials used were: knitted Dacron, 29 grafts; woven Dacron, eight grafts; weave-knit Dacron, 17 grafts; and Dacron external velour, five grafts.

Results

Operative Mortality

Five patients undergoing FF bypass died within 30 days of surgery (operative mortality 15%), three due to postoperative myocardial infarction, one from cerebral hemorrhage, and one from pneumonia.

There were also five early deaths associated with AF bypass resulting in an operative mortality of 8%.

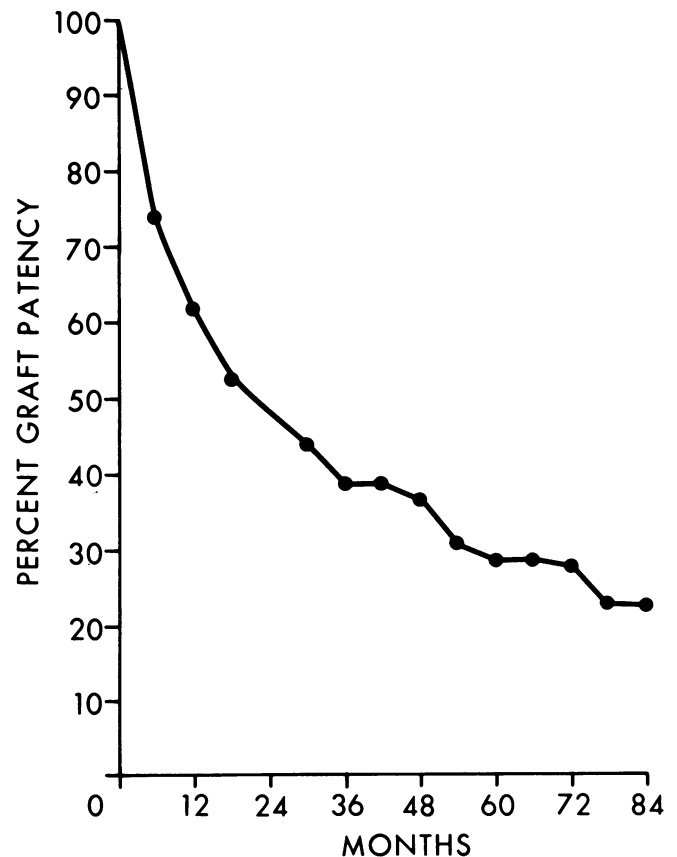


FIG. 3. Patency rate of axillary-femoral bypass grafts determined by life table method (1962-1975).

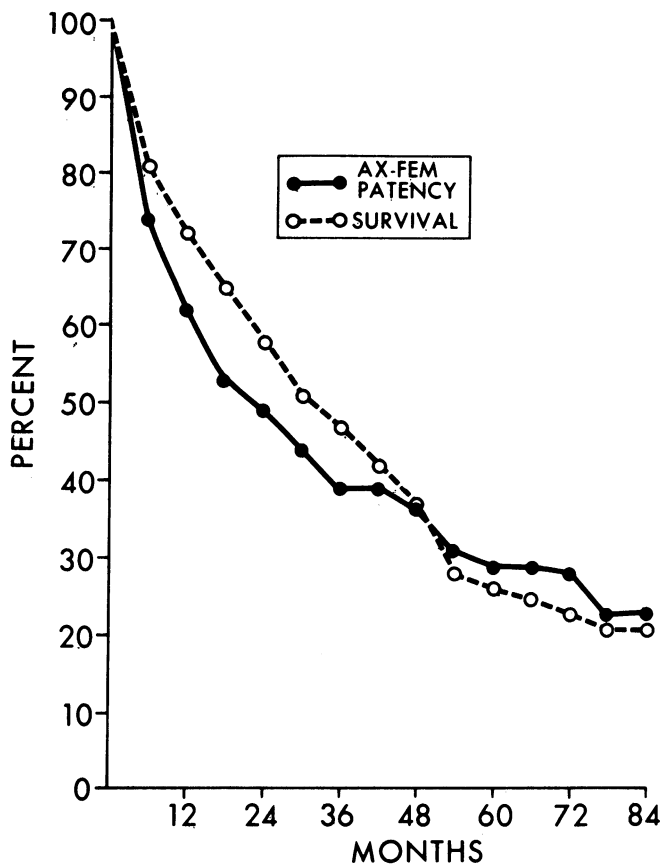


FIG. 4. Comparison of patency of axillary-femoral grafts to patient survival determined by life table method.

The causes of death were: myocardial infarction, cerebral vascular accident, respiratory failure, bowel infarction, and rupture of an abdominal aortic aneurysm.

Symptomatic Results of Operation

Claudication. The 15 patients operated on for intermittent claudication in both groups achieved complete relief of their symptoms.

Rest pain. Of the 16 patients undergoing FF bypass for incapacitating ischemic rest pain, 12 were completely relieved, two experienced improvement of their symptoms, and two were unimproved and subsequently required above-knee amputation. Eighteen patients underwent AF bypass for ischemic rest pain. Thirteen were completely relieved, three patients experienced slight but definite improvement and were able to receive below-knee amputation rather than above-knee amputation, and two patients were unchanged and required above-knee amputation.

Gangrene. Seven patients underwent FF bypass for gangrene: five healed their lesions and became asymptomatic, one patient had a below-knee rather than above-knee amputation, and one patient was un-

changed and required above-knee amputation. Of 20 patients in the AF group 13 became asymptomatic, four had a below rather than above-knee amputation, two were unchanged and had above-knee amputation, and there was one operative death.

Aneurysm. One patient underwent FF bypass for an iliac aneurysm and had an excellent result, i.e., the aneurysm thrombosed and the circulation to the leg remained normal. Five AF bypass operations were performed for abdominal aortic aneurysm. In three cases the aneurysm subsequently thrombosed. Three patients eventually died of complications of the aneurysm, and one patient died in the perioperative period.

Infected aortic prosthesis. Two FF bypasses were performed for infected aorto-femoral grafts (one in a patient who also had rest pain). One patient did well but the other eventually required an A-K amputation. Neither patient experienced further infectious complications. Nine AF procedures were performed for infected aortic prostheses. Two patients died in the immediate postoperative period but the others had an excellent result.

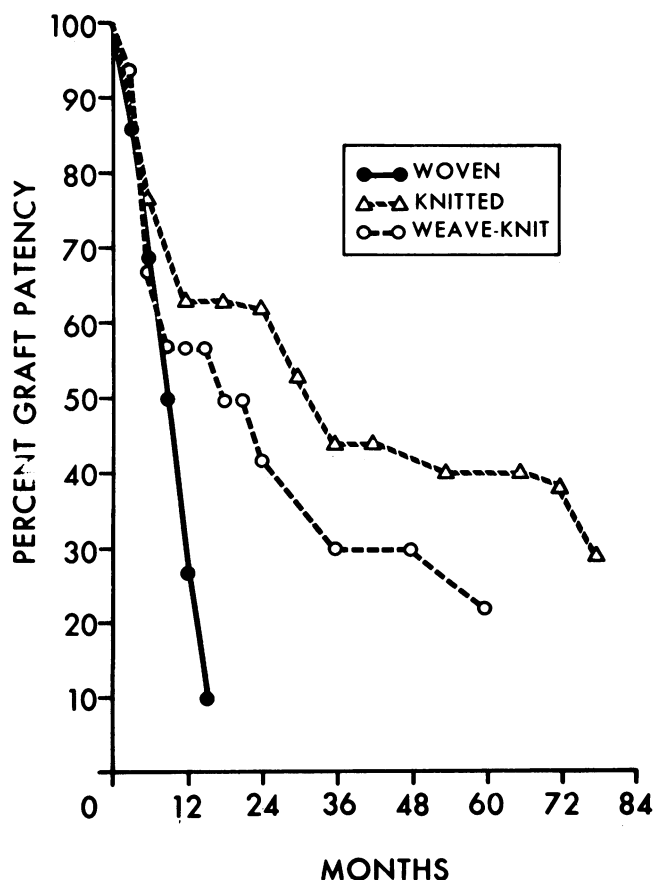


FIG. 5. Comparison of patency of axillary-femoral grafts constructed of woven, knitted, or weave-knit Dacron, showing superior patency of knitted prostheses.

Early complications. There were no postoperative complications in the FF group. In the AF series, there were eight complications: one axillary hematoma, one superficial groin infection, four cases of atelectasis, one case of pneumonia, and one myocardial infarction.

Late complications. The late complications were either graft infection or graft thrombosis. In the FF group one patient developed a graft infection two years following operation. The infected prosthesis was replaced with a venous allograft without further complications. One other patient developed a graft infection three years postoperatively. He too was treated with a venous allograft, which was unsuccessful and he eventually went on to above-knee amputation.

In the AF group, there were three infections occurring from two to 6 months following operation. All were treated by complete graft removal. There were no deaths, but two of the three patients eventually required above-knee amputation.

In each case in which a subcutaneous graft became infected, an infected ischemic lesion on the ipsilateral distal extremity was the primary indication for arterial reconstruction.

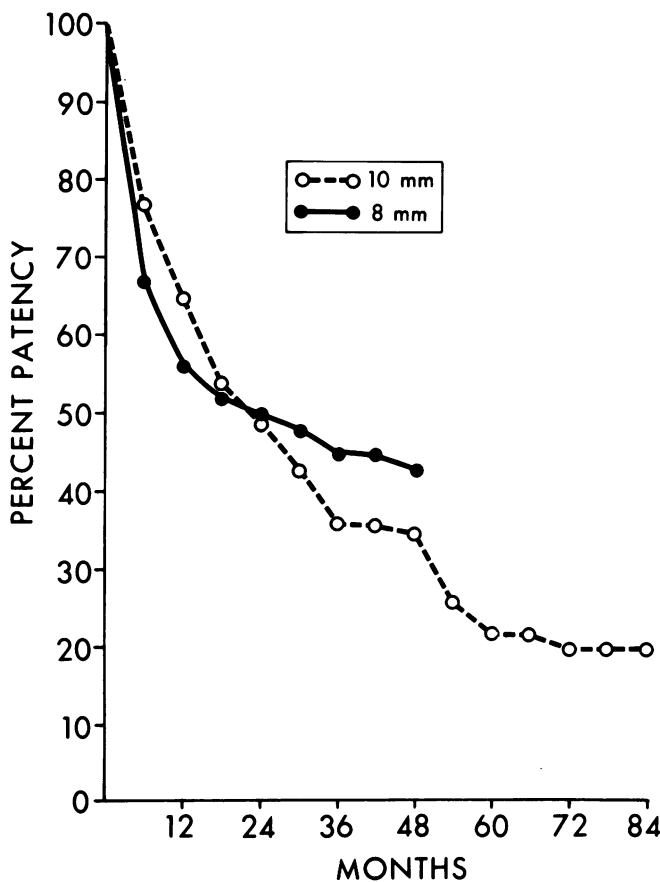


FIG. 6. Comparison of patency curves of axillary-unilateral femoral and axillary-bilateral femoral grafts determined by life table method, showing no significant difference.

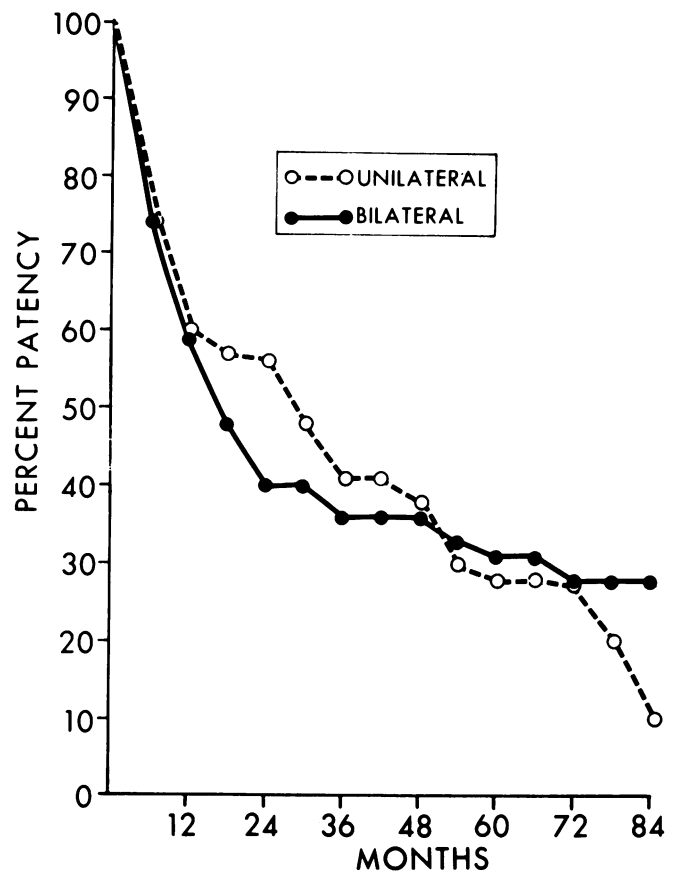


FIG. 7. Comparison of patency curves of axillary-femoral bypass grafts of 10 mm diameter and those 8 mm diameter. There is no significant difference between the two curves.

Patency. Late graft patency was evaluated by the life table method. In the FF series, 74% of the grafts remained patent for one year, 73% for two years, 66% for three years, and 53% for four years (Fig. 1). When the patency curve is compared to a similarly derived curve of patient survival it becomes apparent that the cumulative mortality rate exceeds the cumulative thrombosis rate (Fig. 2).

Figure 3 shows that 50% of the AF grafts had thrombosed by the end of two years. Comparison of the patency curve with the survival curve for this group shows that they are almost identical (Fig. 4). The patency rate of the AF grafts was also analyzed with regard to the type of prosthetic material employed: a 50% incidence of thrombosis was reached at 36 months with knitted Dacron; at 18 months with weave-knit Dacron; and at nine months with woven Dacron (Fig. 5).

There was no statistically significant difference in late patency between unilateral axillary-femoral grafts and axillary-bilateral femoral grafts (Fig. 6). Neither were there significant differences in patency between 8 mm and 10 mm grafts (Fig. 7).

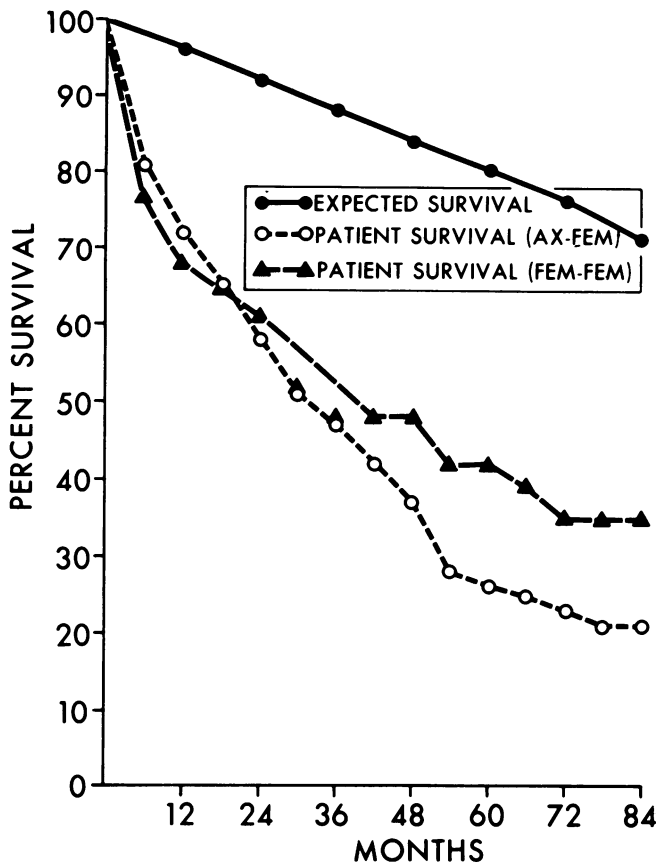


FIG. 8. Comparison of survival of patients undergoing axillary-femoral and femoral-femoral bypass grafts to expected survival of age-matched population.

Late survival. As previously noted, the average age of the patient population in each operative group was 66 years. Based upon U.S. actuarial statistics, the expected five year survival of caucasian males, age 66 is 80%. The five year survival was 42% in our FF group and 26% in the AF group (Fig. 8).

Discussion

Subcutaneous arterial bypass grafts were successfully introduced clinically over 15 years ago for lower extremity revascularization in situations where conventional reconstructions involving the abdominal aorta were contra-indicated or ill-advised.^{2,11} Since then many surgeons have employed them preferentially because of the low morbidity and mortality with which they can be performed. Both clinical and laboratory studies have substantiated the ability of such grafts to provide essentially normal blood flow to the lower extremities. The major problem with these procedures noted in the present series, however, is unsatisfactory long term patency. In the case of the femoral-femoral grafts, the thrombosis rate is acceptably low. Although the cumulative patency of 53% at the end of four

years is lower than that reported in some other series,^{5,6,7,9} it exceeds the cumulative patient survival rate. This reflects the high risk patients who made up the majority of the present series. Furthermore, unlike other series, once a graft thrombosed it was considered permanently thrombosed, even though patency was restored in 8 patients by graft revision and/or replacement and 20 of the 33 (60%) patients had patent grafts at the time of death or conclusion of this study. Several patients have continued to do well for over eight years with multiple graft thrombectomies and/or replacements.

The patency rate of axillary-femoral grafts was not as favorable as for femoral-femoral grafts. Only 50% were patent at the end of two years, and only 14 of the 49 patients (29%) required no secondary revision. Nevertheless, 35 of the 49 (71%) were still patent at the time of death or conclusion of this study.

Several factors could account for the early thrombosis of these grafts, including external compression, inflow or outflow disease, length, diameter, and type of prosthetic material employed, and technical errors. The only variable identified by the present study which appears to significantly affect patency is the type of prosthetic fabrication. Patency of knitted Dacron is superior to woven or weave-knit grafts. This differs from an earlier study¹⁶ in which we reported that 50% thrombosis was reached at 48 months with the weave-knit material compared to 18 months in this review. This discrepancy is due to the fact that the majority of weave-knit grafts studied at the time of the last publication were not yet 18 months old. This premature analysis suggested a falsely high patency rate. In view of the results on longer followup, we no longer use, nor can we recommend weave-knit material for subcutaneous bypass grafting. We are currently evaluating the external velour graft. At this time, however, there are not sufficient data to support a strong recommendation for its use.

Subcutaneous bypass grafts can provide adequate blood flow to the lower extremities, but the long term patency is considerably inferior to conventional aorto-iliac or aorto-femoral reconstruction.^{12,14,15} For example, the five year patency rate for aorto-bilateral femoral grafts in our institution is 85% (12). Therefore, subcutaneous grafts, and in particular, axillary-femoral grafts should not be considered as an equally good alternative method for lower extremity revascularization. They should be reserved for the management of infected aortic prostheses, to bypass intra-abdominal sepsis, to restore lower extremity circulation in poor risk patients with a limited life expectancy, and in selected patients with unilateral iliac artery occlusive disease.

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