Factors Influencing Patency of Femoropopliteal Artery Bypass Grafts

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Recent reports [*1,2*] have suggested that long-term patency of femoropopliteal artery bypass grafts may not be dependent upon the degree of distal runoff. Since this appeared contrary to our experience at the Columbia-Presbyterian Medical Center [*3*], we reviewed 276 femoropopliteal bypass procedures performed on 264 patients from 1954 through 1973. In addition to assessing the role of runoff, we attempted to analyze the effects of concomitant lumbar sympathectomy and postoperative anticoagulation. The relation of the grafting procedure to amputation also was evaluated.

Material and Methods

Indications for operation were rest pain or early gangrene in 68 per cent of patients. Incapacitating claudication, either rapidly progressive or interfering with the patient's ability to earn a living, was the indication in 32 per cent. The average age was sixty-one years. Twenty-four per cent of patients were hypertensive (blood pressure >140/90); 41 per cent were diabetic (fasting blood sugar >110 mg/100 ml). All patients had preoperative arteriograms, and all those available (85 per cent) were reviewed and catalogued into zero (6 per cent), one (21 per cent), two (32 per cent) or three (26 per cent) vessel runoff, depending upon the number of patent branches of the popliteal artery. In all patients, patency after operation was determined by palpation of peripheral pulses. In addition, the functional status of the extremity after operation was graded as either *full* (no symptoms, no limitation of function) or *limited* (rest pain, recurrent incapacitating claudication, gangrene, amputation). Patency and functional results were evaluated by the life table technic, in which patency is recorded for the total number of patients available at the end of each year in follow-up and stated as the cumulative per cent patency.

Follow-up periods have been from one to eighteen years or until amputation or death. For purposes of comparison, results of operations performed in the first ten years of study were separated from results in the last ten year period. Sixty-five patients were surgically treated from 1954 through 1963; 211 procedures were carried out from 1964 through 1973. In addition, a "best risk" subgroup was identified. This group included sixty-nine patients operated on in the last ten years, in whom there was two or three vessel runoff from the popliteal artery, and in whom neither diabetes nor gangrene was present.

Technic. The bypass technic used was similar to that described by Linton and Wilde [*4*] and Szilagyi, Smith, and Elliott [*5*], care being taken not to use veins of too small a caliber for grafts. In 73 per cent of patients, a suitable vein was available for use. In 27 per cent of patients, a suitable vein was not available, and a Dacron® prosthesis was used. Sympathectomy was performed, in addition to bypass, in 148 patients (54 per cent); and anticoagulation was used in 153 instances (55 per cent). Heparin, either deep subcutaneous or intravenous, was used perioperatively and for ten days after operation. Clotting time was kept in the range of one to two times normal values 5.5 hours after a dose of heparin. For long-term anticoagulation, coumarin or sodium warfarin was used and controlled by prothrombin time, which was kept in the range of twice normal values.

Results

The overall patency rate for grafts in this study was 58 per cent at one year and 40 per cent at five years. (Figure 1.) Results were poorest in the first ten year operative group, better in the second ten year group, and best in the "best risk" subgroup. (Table I.) The one year patency rate includes early postoperative failures, but does not include early postoperative deaths. There were twelve early postoperative deaths and fifty-seven graft failures within the first thirty days after operation. Of the 207 patients who left the

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hospital with a patent graft, the one year patency rate was 71 per cent (147/207).

At each stage in follow-up, and in each group, the percentage of patients having good functional extremities exceeded the percentage of those with patent grafts. (Figure 2.) The overall percentage of fully functional extremities one year after operation was 69 per cent; at five years, it was 57 per cent. As with patency, functional results were better in the second ten year group, and best in the "best risk" subgroup. (Table II.)

Graft patency was directly related to the outflow from the popliteal artery. (Figure 3.) In the presence of three or two vessel runoff, the overall five year patency rates were 57 and 48 per cent, respectively. For one and zero vessel runoff, the five year patency rates were 30 and 0 per cent, respectively.

The patency rate for vein grafts exceeded that for Dacron grafts at each interval in follow-up. The overall five year patency rate for vein grafts was 48 per cent and for Dacron, 19 per cent. The question of possible bias in the distribution of cases, which might have favored patency of vein grafts, was considered. In the Dacron group, there were somewhat fewer patients with two and three vessel runoff, but the number with early gangrene was similar in both groups. The Dacron prosthesis group was small, however, and comparison of patency in the two groups is probably not valid in this series.

Results in diabetics were similar to those in nondiabetics in terms of graft patency and in the percentage of fully functional extremities at each interval in follow-up [6,7]. Consideration was given to the possibility of bias favorable to patency of grafts

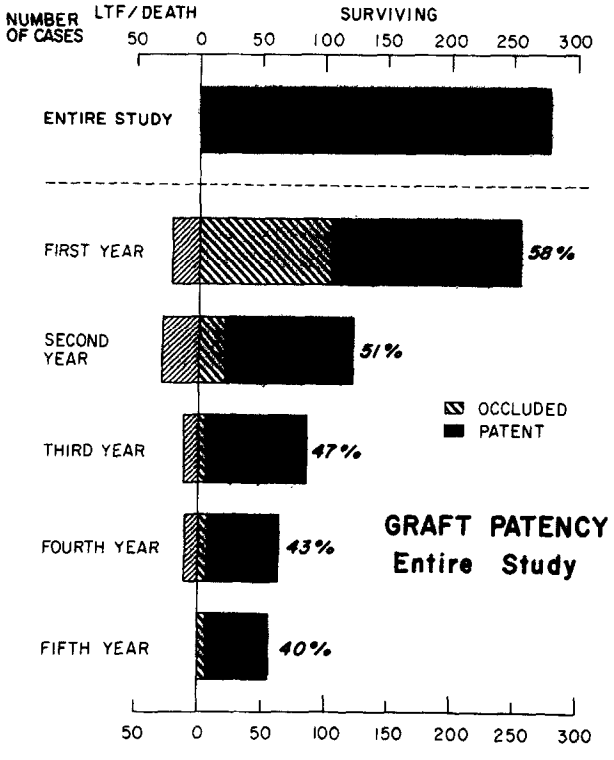

Figure 1. Graft patency in entire study.

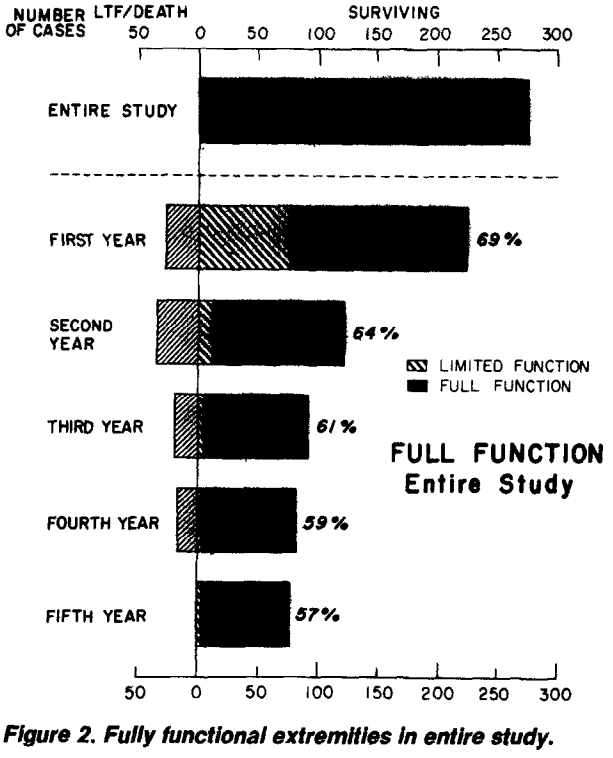

Figure 2. Fully functional extremities in entire study.

TABLE I Graft Patency

Year	Entire Study (%)	First 10 Years (%)	Second 10 Years (%)	"Best Risk" Group (%)
1	58	46	61	76
2	51	40	54	61
3	47	35	51	52
4	43	33	46	49
5	40	30	42	43

TABLE II Fully Functional Extremities

Year	Entire Study (%)	First 10 Years (%)	Second 10 Years (%)	"Best Risk" Group (%)
1	69	59	72	87
2	64	51	67	82
3	61	49	63	74
4	59	46	62	74
5	57	46	60	74

TABLE III Distribution of Runoff and Early Gangrene

Factor	Entire Study (276)*	Diabetic (116)	Sympathectomy (148)	Anticoagulation (153)
Runoff				
0 Vessel	6% (17)	8% (9)	7% (10)	5% (7)
1 Vessel	21% (58)	24% (28)	24% (36)	26% (40)
2 Vessel	32% (87)	32% (37)	31% (46)	33% (51)
3 Vessel	26% (72)	21% (24)	26% (38)	23% (35)
(?) Vessels	15% (42)	16% (18)	12% (18)	13% (20)
Early gangrene	28% (76)	39% (45)	31% (46)	29% (44)

* Number of patients in each group.

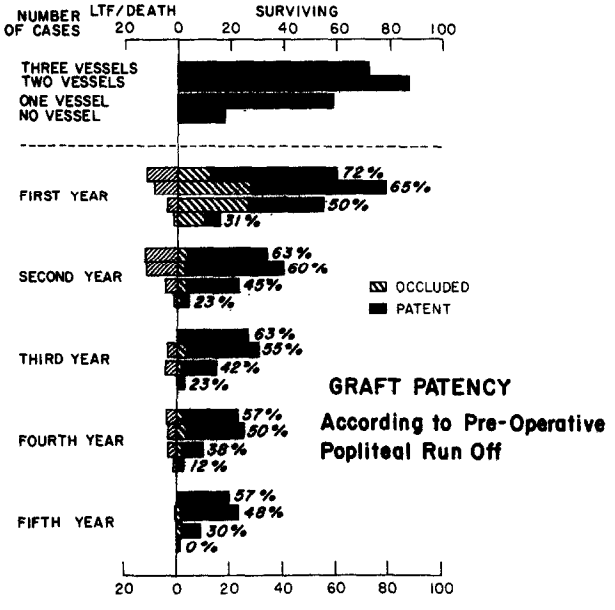

Figure 3. Graft patency according to preoperative popliteal artery runoff.

in the diabetic group, as compared with the entire study. (Table III.) The incidence of preoperative early gangrene was higher in the diabetic group; the distribution of number of vessels in the outflow tract was similar to that in the entire study group.

Patients who had sympathectomy as well as a bypass procedure did no better than patients treated with bypass alone. (Figure 4.) The possibility that patients in the sympathectomy group were poorer risk individuals was evaluated. This was found not to be the case. Although the addition of sympathectomy to the bypass procedure was the individual surgeon's decision, the distribution of runoff and early gangrene in the sympathectomy group was similar to that in the entire group. (Table III.) The addition of sympathectomy to the bypass procedure did not appear to improve long-term patency or function. The incidence of the use of Dacron grafts in the sympathectomy group was similar to that in the entire study. The majority of sympathectomies (116/148) were done in the last ten years. The possibility that sympathectomy contributed to the improved patency and functional results in the second ten year period was considered and found not to be the case.

Anticoagulation did not affect patency rates in the overall series. (Figure 5.) No significant difference in runoff and early gangrene could be detected in the anticoagulation group when compared with the entire study. (Table III.) The incidence of use of Dacron grafts in the anticoagulation group was similar to that in the entire study.

Amputation. In the entire series, forty-eight patients (17 per cent) required amputation. Thirty-five patients had presented with early gangrene and twenty-three were diabetic. Of ninety patients in whom claudication was the indication for operation, three (3 per cent) required amputation (3 days and 1 and 4 years postoperatively).

As expected, the majority of amputations occurred in those patients with zero and one vessel runoff. Of seventy-two patients with three vessel runoff preoperatively, four (6 per cent) required amputation after graft occlusion. Two of these patients had coexistent iliac stenosis, which may have contributed to graft failure. One patient had a compound femoral fracture with extensive tissue loss. In the fourth instance there was no obvious cause for graft failure. Of eighty-seven patients with two vessel runoff, nine (10 per cent) required amputation after graft failure. In two instances, extensive iliac stenosis was present. In two patients, technical problems may have been the cause of graft failure. In five patients, no cause for occlusion could be found. Of fifty-eight patients with one vessel runoff, fourteen (24 per cent) required amputation after graft failure. Of seventeen patients with zero vessel runoff, twelve (71 per cent) went on to require amputation.

Fifty-seven grafts occluded within the first thirty days after operation. Of these, twenty-nine required amputation. These early amputations were attrib-

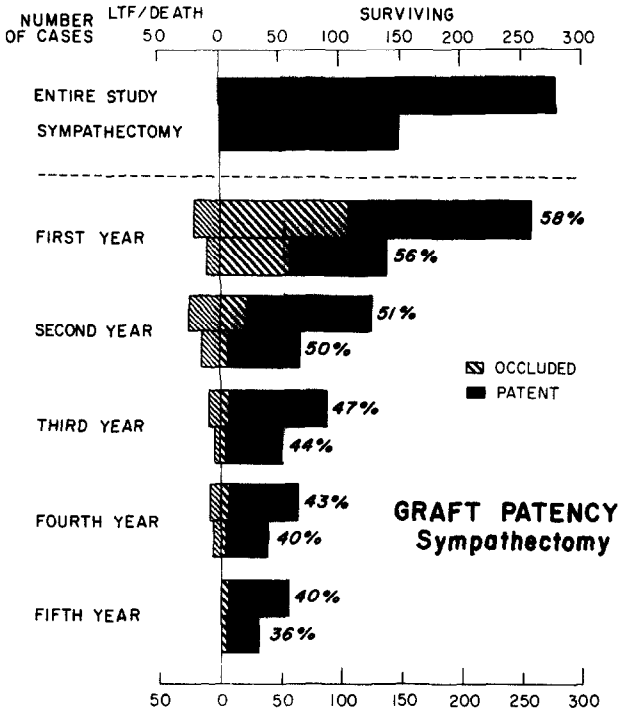

Figure 4. Graft patency in patients with sympathectomy in addition to bypass.

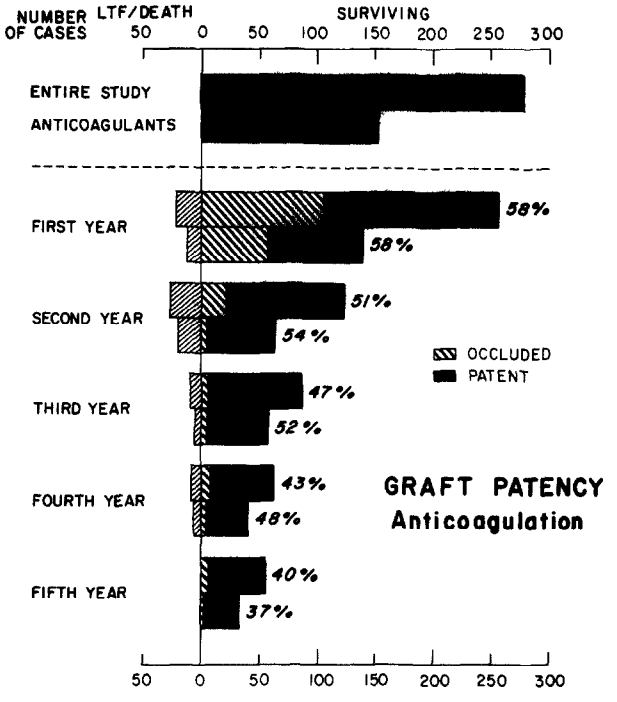

Figure 5. Graft patency in patients in whom anticoagulation was used postoperatively.

uted to inadequate runoff in fourteen patients and to technical factors in four patients. In the remaining eleven early amputations, there was no obvious cause for graft failure.

Of the forty-eight patients requiring amputation, thirty had sympathectomy in addition to bypass. Sympathectomy did not decrease the rate of amputation after graft occlusion in the first thirty days post operation. In addition, sympathectomy did not affect the amputation rate after graft occlusion within the first year post operation. Of the seven amputations required for occlusion later than one year after bypass, five had sympathectomy in addition to bypass. In the entire group of forty-eight amputations, there was no significant difference in the level of amputation in the group that had sympathectomy when compared with the group that did not have sympathectomy.

Mortality. In this study, the Operative mortality was 4.5 per cent. Six deaths, secondary to cardiac causes, occurred within the first five days post operation. A seventh patient died after a myocardial infarction on the thirty-sixth postoperative day. Five additional deaths were caused by gangrene, sepsis, gastrointestinal hemorrhage, pneumonia, renal failure, and stroke, up to two months post operation.

Reoperations. In addition to 276 primary operations, forty-six reoperations were performed for forty acute graft occlusions, five suture line aneurysms, and one infected graft. New grafts were used in nineteen instances, and thrombectomy was performed in twenty-one patients. Two grafts were removed, and exploration alone was carried out in four instances. At one year after reoperation, thirteen of nineteen new grafts were patent; at five years, four of nineteen remained patent. One year after reoperation, ten of twenty-one grafts treated with thrombectomy were patent; at five years, two of twenty-one remained patent.

Comments

It is clear in this series that immediate and late graft patency rates were directly related to the degree of outflow distal to the graft. The patency rate in patients with two or three vessel runoff was far superior to that in patients with zero or one vessel runoff. It is true that operations were performed for more advanced disease than has been reported generally; two thirds of patients had rest pain or early gangrene and may be compared with the group reported by Dale [8]. However, we do not feel that the severity of disease in any way influenced the relationship between graft patency and the degree of popliteal runoff, as determined by preoperative arteriography.

Both graft patency and functional results were better in the last ten year period. Although technical factors and ability of the surgeons may have played a role in the improved results, it is probable that changing indications for operation and better selection of patients were the most important factors. Patients with little chance for success (advanced gangrene, no outflow) are no longer considered for bypass procedures. In addition, more patients with claudication alone have undergone operation in recent years.

It was interesting to learn that some patients with occluded grafts had good functional results. One may speculate that the presence of a temporarily functioning graft may have led to increased collateral circulation and dilatation of the peripheral arterial bed. Although laboratory studies suggest the opposite [*9*], it seems most reasonable to conclude from this clinical observation that some additional arterial blood flow did develop in extremities of patients in whom grafts occluded.

The failure to be able to clearly demonstrate some beneficial effect from sympathectomy was disappointing. Although vasospasm may be decreased by sympathectomy and blood flow to the skin increased [*10*], sympathectomy did not alter early or late graft patency in this series.

The finding that anticoagulation did not significantly improve graft patency is similar to experiences in other institutions [*8,11*].

The rate of amputation in this series was high (17 per cent), reflecting the preponderance of cases with advanced disease and poor outflow. In ninety patients with claudication alone, acute occlusion of the graft was followed by gangrene and loss of the extremity in three patients. Two of these patients had excellent runoff (3 vessels). Although there is a risk of amputation after a bypass procedure in patients with claudication alone, this 3 per cent amputation rate is lower than that cited by Boyd [*12*] (7 per cent) for patients with claudication followed five years without operation.

Summary

An analysis of 276 femoropopliteal bypass procedures performed in 264 patients at the Columbia-Presbyterian Medical Center over the past two decades showed a direct relationship of graft patency to preoperative popliteal artery runoff. Functional results were better than patency results. Sympathectomy and anticoagulation did not improve graft patency. The risk of amputation is outweighed by the benefits of restoration of blood flow to the ischemic extremity by a bypass procedure.

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