The impact of patient age and aortic size on the results of aortobifemoral bypass grafting

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Objectives: **On the basis of the widespread belief that aortobifemoral bypass (ABF) represents the optimal mode of revascularization for patients with diffuse aortoiliac disease, vascular surgeons are often aggressive about its application in young adults. We undertook this retrospective evaluation of ABFs performed from 1980 to 1999 to determine whether the results justify this approach. Patients of less than 50 years of age (n = 45) were compared with those aged 50 to 59 years (n = 93) and those aged more than 60 years (n = 146).**

Results: **Younger patients were more likely to undergo operation for claudication than were older patients (72% versus 59% and 55%; $P < .04$). Younger patients were significantly more likely to be smokers (87%) but less likely to have diabetes, hypertension, or cerebrovascular disease. Bypasses were constructed in an end-to-end fashion in 71.1% of patients of less than 50 years versus 68.8% and 71.2% of older patients (P = not significant). The mean diameter of aortic grafts was significantly smaller in younger patients (14.6 mm) than in older patients (15.6 mm and 15.5 mm; $P < .01$). The need for a subsequent infrainguinal reconstruction was highest in the youngest patients (24% versus 17% and 7%; $P < .01$). Surgical mortality rates were low in all groups (0%, 1%, and 2.0% for increasing age groups; P = not significant). Five-year primary and secondary patency rates increased significantly with each increase in age interval: 5-year primary patency rate: less than 50 years, 66% ± 8%; 50 to 59 years, 87% ± 5%; more than 60 years, 96% ±2% ($P < .05$ for all comparisons). Five-year secondary patency rates were: less than 50 years, 79% ± 7%; 50 to 59 years, 91% ± 4%; more than 60 years, 98% ± 2% ($P < .05$ for all comparisons). Five-year survival rate was comparable in all three groups: less than 50 years, 93% ± 5%; 50 to 59 years, 92% ± 4%; more than 60 years, 87% ± 4% (P = not significant).**

Conclusion: **Increased virulence of aortic disease, smaller aortic size, and more progressive infrainguinal disease may all negatively impact the results of ABF in younger patients. Although 5-year results are acceptable, increased caution is warranted in the routine application of ABF in young patients without limb-threatening ischemia. (J Vasc Surg 2003;37: 1219-25.)**

Premature atherosclerotic disease of the lower extremities in the young adult before age 50 years has been associated with rapid progression of disease and a higher incidence rate of graft occlusion.[1-3] Aortobifemoral bypass (ABF) has long been thought to represent the optimal mode of revascularization for patients with diffuse aortoiliac disease; thus, vascular surgeons are often aggressive about its application in young adults. We undertook this retrospective evaluation of ABFs performed from 1980 to 1999 to determine whether the results justify this approach.

PATIENTS AND METHODS

A retrospective evaluation was performed on all ABF grafts done consecutively at the Brigham and Women's Hospital between January 1980 and December 1999. Data were retrieved from a computerized registry in which demographics, risk factors, procedure variables, and follow-up information have been prospectively entered for all vascular surgery patients at our institution since 1975. A detailed review of computerized inpatient records, office charts, operative reports, vascular laboratory reports, and angiographic findings was performed.

Aortic graft size was selected to optimize the size match with the native vessels and used as a surrogate for actual aortic diameter, which was not measured. The type of proximal anastomosis (end-to-end versus end-to-side) was determined by the surgeon on the basis of occlusive external iliac disease or a wish to avoid sacrificing a large patent inferior mesenteric artery. The distal anastomosis was constructed to the common femoral artery when both angiographic and intraoperative assessment deemed the superficial femoral and profunda femoris arteries to be widely patent. If this was not the case, the anastomosis was carried onto the profunda femoris artery. Typical postoperative care included short-term monitoring in the surgical intensive care unit with β blockade and aspirin.

Follow-up examinations occurred within the first month of surgery, then at 3-month intervals during the first year, followed annually thereafter. Patency was easily confirmed with the presence of palpable femoral pulses and, when necessary, appropriate vascular laboratory studies. A return of symptoms or change in physical examination prompted further work-up, leading to intervention when appropriate.

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Competition of interest: none.

Presented at the Twenty-eighth Annual Meeting of the New England Society for Vascular Surgery, Providence, RI, Sep 19-21, 2001.

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Published online Mar 6, 2003.

0741-5214/2003/$30.00 + 0

doi:10.1016/S0741-5214(02)75179-3

Table I. Characteristics of study population (n = 281)

Variable	*Percent*	*Mean (SD)*
Patient characteristics		
Age		60.1 (9.4)
<50 y	14.6%	
50-59 y	33.5%	
>60 y	51.4%	
Gender (male)	58.0%	
Smoker	71.5%	
History of diabetes	20.6%	
History of hypertension	55.2%	
History of coronary artery disease	46.3%	
History of CABG	12.8%	
History of cerebrovascular disease	6.8%	
History of COPD	17.8%	
History of chronic renal insufficiency	3.2%	
History of congestive heart failure	6.4%	
Procedure characteristics		
Decade of procedure (1990s)	54.8%	
Graft size (mm)		15.4 (1.6)
Indication (claudication versus salvage)	59.1%	
Runoff		
Common femoral artery	88.2%	
Profunda femoral artery	7.9%	
Proximal superficial femoral artery	3.9%	
Type of anastomosis		
End-end	70.0%	
End-side	30.0%	
Subsequent outflow procedure performed	13.5%	

SD, Standard deviation; *CABG,* coronary artery bypass grafting; *COPD,* chronic obstructive pulmonary disease.

Table II. Characteristics of study population by age group

Risk factors	*<50 y*	*50-59 y*	*>60 y*
Smoking	39 (87%)*	72 (77%)*	93 (64%)
Male gender	22 (49%)†	66 (71%)*	77 (53%)
Female gender	23 (51%)†	27 (29%)*	69 (47%)
Hypertension	16 (36%)*	46 (49%)*	93 (64%)
Coronary artery disease	26 (58%)	39 (42%)	67 (46%)
Prior CABG	5 (11%)	9 (10%)	21 (14%)
Diabetes	4 (9%)*	23 (25%)	32 (22%)
Chronic pulmonary disease	8 (18%)	10 (11%)*	33 (23%)
Cerebrovascular disease	0 (0%)*	6 (6%)	13 (9%)
Chronic renal disease	0 (0%)	4 (4%)	5 (3%)
Claudication	32 (71%)*	55 (59%)	80 (55%)
Limb salvage	13 (29%)*	38 (41%)	66 (45%)
Previous inflow procedure	10 (22%)*	18 (19%)*	13 (9%)
Iliac angioplasty	6 (13%)*	9 (10%)*	5 (3%)
ABF	5 (11%)	4 (4%)	5 (3%)

All *P* values not significant except where noted.
*$P < .05$ when compared with >60 years group.
†$P < .05$ when compared with 50 to 59 years group.
CABG, Coronary artery bypass grafting.

Limb salvage was defined as freedom from major amputation. Primary patency (PP) and secondary patency (SP) were defined in accordance with the suggested reporting standards of the Ad Hoc committee of the Society for Vascular Surgery and the North American Chapter of the International Society for Cardiovascular Surgery.[4] Survival, graft patency, and limb salvage rates were calculated with the life-table method. Failures were defined as an occluded graft as determined with arteriography or with loss of palpable femoral pulses. Limb salvage rates were assessed only in those patients who underwent operation for limb salvage. Standard errors were calculated with the Greenwood method, and comparisons were made between groups with the Mantel-Cox log-rank analysis. Categoric variables listed in Table I were compared with χ^2 analysis. A *P* value of less than .05 was considered to represent statistical significance. Cox proportional hazards regression methods were used to model the relationship between graft occlusion and the covariates described in Table I. As there were only a limited number of graft failures, conventional multivariate analysis could not be applied because, in general, discrete data analysis suggests that only one variable for every 10 to 15 cases evaluated should be analyzed[5] (ie, if only 20 occlusions were noted in a data set, sufficient power existed for testing two variables at the most). Additional matched analyses were performed to eliminate confounding variables. Length of follow-up data was analyzed with Student two-tailed *t* test. Patients were censored if they died or were lost to follow-up or at the termination of the study. Lost to follow-up was defined as the last patient visit or contact being more than 18 months before the completion of the study at the end of 1999.

RESULTS

During the 20-year period, 284 ABF grafts were performed in 281 patients. One hundred twenty-seven (45%) were completed in the 1980s, and 157 (56%) in the 1990s. Forty-five patients were less than 50 years old, 93 patients were 50 to 59 years old, and 146 patients were more than 60 years of age. There were 165 men and 119 women, with 51% of the patients under the age of 50 years comprised of women. Risk factors included smoking (79%), hypertension (55%), and coronary artery disease (46%), with 13% of patients having undergone previous coronary artery bypass grafting (Table I). Younger patients of less than 50 years of age were significantly more likely to be active or former smokers when compared with those who were more than 60 years old (87% versus 64%, respectively; $P < .002$) but were less likely to have diabetes, hypertension, or cerebrovascular disease or to undergo operation for limb salvage ($P < .05$ for all comparisons), as shown in Table II. There were significantly more women in the group of less than 50 years old compared with the 50 to 59 year olds, but no difference was noted when compared with those more than 60 years (Table II).

Overall, 59% of aortobifemoral reconstructions were performed for claudication and 41% for limb salvage (rest pain, 26%; ulcer, 11%; gangrene, 4%), with significantly more patients undergoing operation for limb salvage in the older age group compared with the younger age group (Table II). Fifteen percent of all patients had undergone previous inflow procedures, with significantly more in those

less than 50 years and 50 to 59 years compared with those more than 60 years (Table II). Of the previous inflow procedures performed, a significantly higher number of iliac angioplasties were done in both the less than 50 years and 50 to 59 years age groups when compared with patients more than 60 years, with no appreciable difference when considering prior ABF bypass grafts (Table II). Six percent of patients had previous infrainguinal reconstruction (P = not significant for all age groups).

Graft material consisted of woven or knitted polyester in 44% of patients, collagen-coated Dacron grafts in 55%, and polytetrafluoroethylene in 1%. Seventy percent of patients had the proximal anastomosis constructed in an end-to-end fashion, with 30% end-to-side (P = not significant for all age groups). The mean graft diameter was significantly smaller in younger patients compared with those more than 50 years old (14.6 mm versus 15.6 and 15.5 mm; $P < .01$). The distal anastomosis was constructed to the common femoral artery with and without extension onto the profunda femoris in 88% of patients (<50 years, 86%; 50 to 59 years, 92%; >60 years, 86%), the profunda femoris in 8% (<50 years, 11%; 50 to 59 years, 6.5%; >60 years, 11%), and the proximal superficial femoral artery in 4% (<50 years, 3%; 50 to 59 years, 6%; >60 years, 3%), with no significant difference between age groups ($P > .5$ for all comparisons).

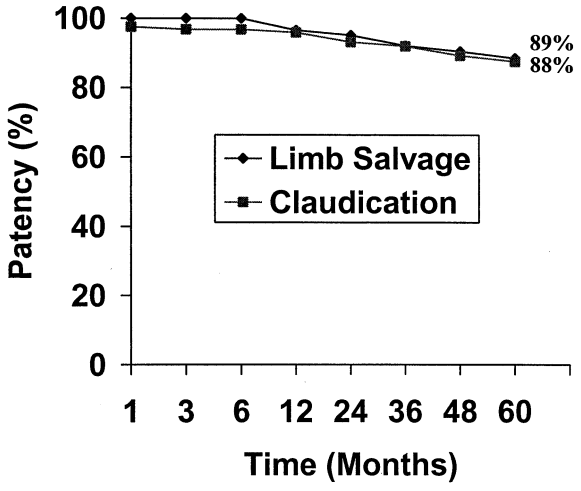
The overall postoperative morbidity rate was 32%, including cardiac complications (15%: arrhythmia, 12%; myocardial infarction, 2%; congestive heart failure, 1%), gastrointestinal problems (8%: prolonged ileus, 5%; ischemic colon, 1%; gastrointestinal bleed, 1%; hepatic failure, 1%), wound infections (3.5%), and renal failure (3.2%). Major morbidity (myocardial infarction, stroke, and renal and pulmonary failure) occurred in 9%. Early (<30 days) graft failure occurred in four patients (1%; two patients <50 years old, 2%; two patients 50 to 59 years old, 2%; 0 patients >60 years old). No significant difference was noted between the three age groups in postoperative morbidity or mortality rates; however, the less than 50 years and 50 to 59 years groups were more likely to have early graft failure when compared with the more than 60 years group (<50 years, 2%; 50 to 59 years, 2%; >60 years, 0; $P < .05$ when <50 and 50 to 59 years compared with > 60 years). Overall, the 30-day operative mortality rate of 1% (<50 years, 0 patients; 50 to 59 years, 1 patient; >59 years, 3 patients) was from congestive heart failure, myocardial infarction, respiratory failure, and multisystem organ failure, with no significant difference between age groups. The mean follow-up period was 48 months (range, 1 to 236 months), with a significantly longer follow-up period in the younger age group (mean, 65 months) compared with the more than 60 years group (mean, 45 months; $P < .016$). One hundred twelve patients (39%) were lost to follow-up.

The overall 5-year cumulative PP rate was 85% ± 3%, with a SP rate of 92% ± 2% (Table III). No difference in the overall 5-year cumulative PP rate was noted when comparing claudication versus limb salvage (Fig 1) as an indication for operation nor in comparing PP rate in male versus female (Fig 2) subgroups (Table III). There was also no significant difference in overall 5-year cumulative PP rate when comparing end-to-end versus end-to-side configuration of the proximal anastomosis (Fig 3; Table III). The PP rate improved progressively with each age group (Fig 4), with a 5-year cumulative PP rate of 66% ± 8% in the less than 50 years group compared with 87% ± 5% in the 50 to

Table III. Life-table analysis of ABF grafts

Characteristics or indication for surgery	*5-y PP rate*	*5-y SP rate*
Overall	85.0% ± 2.6%	92.5% ± 2.2%
P value	NA	NA
Claudication	87.7% ± 3.4%	91.7% ± 2.9%
Limb salvage	88.7% ± 3.8%	93.7% ± 3.1%
P value	.421	.319
Male gender	89.7% ± 3.4%	94.8% ± 2.6%
Female gender	86.6% ± 3.8%	90.6% ± 3.5%
P value	.271	.169
<50 y	65.7% ± 8.4%	79.2% ± 7.2%
50-59 y	87.3% ± 4.8%	91.4% ± 4.2%
>60 y	97.5% ± 1.7%	98.8% ± 1.2%
P value	*	*
End-to-end	89.1% ± 3.0%	93.4% ± 2.5%
End-to-side	85.8% ± 4.7%	92.3% ± 3.7%
P value	.278	.401

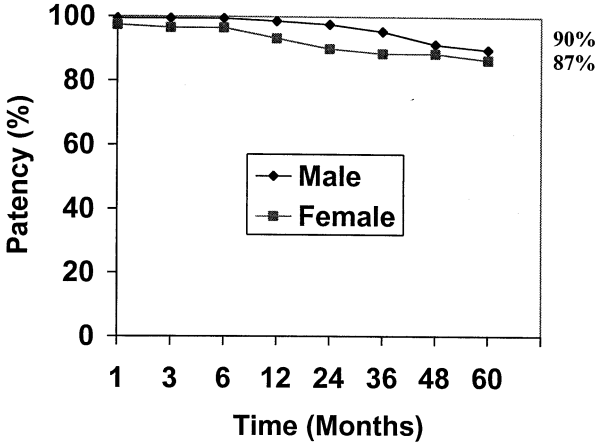
*$P < .05$ for all comparisons.
NA, Not applicable.



Number of grafts at risk*

Claudication	167	150	140	125	111	93	75	57
Limb Salvage	117	109	99	92	79	67	60	51

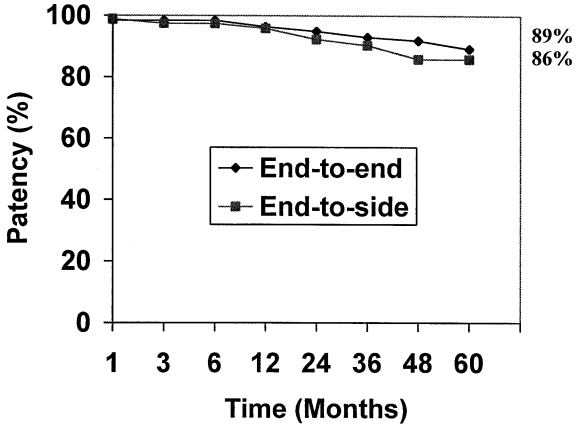
Fig 1. Life-table analysis of cumulative PP rates for ABF grafts according to indication.



Number of grafts at risk*

Male	165	150	136	123	109	94	78	61
Female	119	109	103	94	81	66	57	47

Fig 2. Life-table analysis of cumulative PP rates for ABF grafts according to gender.

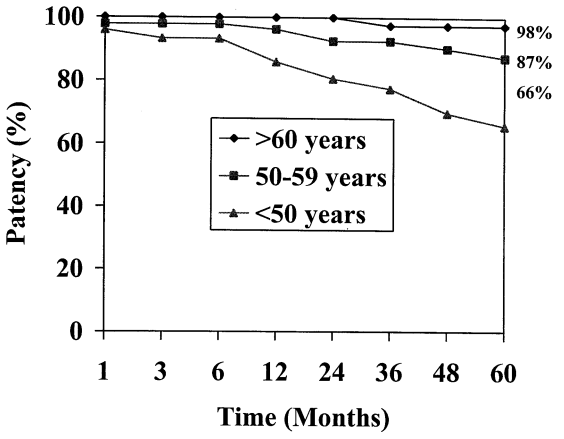


Number of grafts at risk*

End-to-end	200	181	171	155	133	110	90	73
End-to-side	84	78	68	62	57	50	45	35

Fig 3. Life-table analysis of cumulative PP rates for ABF grafts according to proximal anastomosis configuration.

59 years group and 96% ± 2% in the more than 60 years group ($P < .05$ for all comparisons). A similar improvement in progression in SP rate was also noted between age groups, with a 5-year cumulative SP rate of 79% ± 7% in the less than 50 years group, 91% ± 4% in the 50 to 59 years



Number of grafts at risk*

>60 years	146	133	124	112	100	87	72	56
50-59 years	93	84	75	66	56	45	41	35
<50 years	45	42	40	39	34	28	22	17

Fig 4. Life-table analysis of cumulative PP rates for ABF grafts according to age.

group, and 99% ± 1% in those more than 60 years (Table III). The 5-year cumulative survival rates were 93% ± 5%, 92% ± 4%, and 87% ± 4%, respectively, in the increasing age groups (P = not significant). The younger age group was more likely to require subsequent infrainguinal reconstruction in the follow-up period (24%) when compared with the older age group (7%; $P < .001$).

In a univariate analysis evaluating variables predictive of graft failure, age ($P < .0001$), aortic size ($P < .0004$), and hypertension ($P < .04$) were found to be significant variables (Table IV). Conditional logistic regression analysis then was used to analyze age-matched case controls to eliminate the potential confounding effect of age on the other significant variables of interest (Table V). When correcting for patient age, aortic graft size remained a significant predictor of graft occlusion (risk ratio, 0.7/mm graft size; $P < .03$), showing that larger graft size had a significant protective effect, independent of age. When adjusted for graft size, age remained highly significant (risk ratio, 0.9/y; $P < .002$), suggesting a 10% risk reduction of graft occlusion for every 1-year increase in age, independent of graft size.

DISCUSSION

Symptomatic atherosclerosis in young adults has been reported in the literature as a poor prognostic finding because of multiple vascular bed involvement and the accelerated nature of the disease process.[6-9] Other investigators have noted, however, that younger patients have more localized aortic atherosclerosis.[10] Our study directly compared 45 patients of less than 50 years of age with groups

from 50 to 59 years of age (n = 93) and of more than 60 years of age (n = 146) and found that younger patients had significantly inferior patency rates, with a 66% 5-year cumulative PP rate compared with 96% in the older age group ($P < .05$). We determined that age and aortic size were important predictors for graft failure. We did not appreciate differences in patency when looking at construction of the proximal anastomosis or gender.

Our findings of inferior long-term patency in young adults are consistent with those of Valentine et al,[11] who reported a 65% 3-year cumulative graft patency rate, and Olsen and colleagues,[3] who found 34% of younger patients needed further intervention to maintain long-term patency after ABF bypass. Why patients with premature atherosclerosis are prone to failure after revascularization is not clear. Perhaps a more virulent form of atherosclerosis or even more aggressive intimal hyperplasia exists in this age group. A significantly higher number of our younger patients had undergone previous inflow procedures when compared with the older age group. Although the multivariate analysis did not prove this to be a predictor of future graft failure in the less than 50-year-old patient, it could be a marker of virulent atherosclerotic disease that may account for poor patency rates. It may also suggest multisegmental disease in young patients—a point that remains controversial in the literature.[12] We did find that younger patients had a significantly higher rate of subsequent infrainguinal reconstruction when compared with the older age group; however, this may be in part from a longer period of follow-up.

Our analysis also revealed that patients with smaller aortas had poorer long-term patency rates, consistent with findings by Valentine et al[11] and others.[13,14] Others have reported that graft size, our surrogate for aortic diameter, is not a factor. Schneider et al[15] found no difference in 3-year SP rate between patients with small diameter grafts versus those with larger diameters. Although we found small aortic graft size to be a risk factor for occlusion, it is unclear whether small aortic size, small graft size, or perhaps both are contributors to the lower patency rates. We hypothesize that a smaller aorta may be less accommodating to intimal hyperplasia or perhaps result in a lower threshold for thrombosis. This may also hold true in the periphery where patients with smaller aortas likely have smaller outflow vessels in the groin more prone to hemodynamic compromise. Although we did not measure the size of the distal arteries in our retrospective study, others have done so and found a close association between small aortic size and small peripheral arteries.[10]

We did not find gender to be a risk factor for graft occlusion, in keeping with the findings of Valentine et al,[11] who found the size of the infrarenal aortic segment the critical determinant of late graft patency, regardless of gender. Similarly, Schneider et al[15] noted a 92% 3-year patency rate in women versus 82% in men ($P = .53$). We also found no difference in patency related to the configuration of the proximal anastomosis, which is consistent with findings of others.[11,15]

Table IV. Crude relationships between potential predictors and graft occlusion

Variable	*Relative risk ratio for failure*	*95% CI*	P *value*
Patient characteristics			
Age*	0.91	(0.87, 0.95)	<.0001
Gender (male)	0.71	(0.30, 1.68)	.4373
Smoker	3.63	(0.84, 15.57)	.0833
History of diabetes	0.34	(0.08, 1.48)	.1509
History of hypertension	0.37	(0.14, 0.94)	.0373
History of coronary artery disease	0.52	(0.21, 1.29)	.1565
History of COPD	0.43	(0.10, 1.86)	.2613
Procedure characteristics			
Decade of procedure (1990s)	0.55	(0.22, 1.36)	.1948
Graft size (mm)†	0.56	(0.41, 0.77)	.0004
Indication (claudication versus salvage)	1.55	(0.62, 3.83)	.3475
Type of anastomosis (end-side versus end-end)	1.39	(0.44, 4.37)	.5793
Subsequent outflow procedure performed	1.70	(0.66, 4.43)	.2748

*Relative risk ratio for failure is for 1-y increase in age.
†Relative risk ratio for failure is for 1-mm increase in graft size.
COPD, Chronic obstructive pulmonary disease.

Table V. Age-adjusted relationships between predictors with crude *P* values <.20 and graft occlusion

Variable	*Age-adjusted rate ratio*	*95% CI*	P *value*
Patient characteristics			
Smoker	2.09	(0.47, 9.30)	.3331
History of diabetes	0.40	(0.09, 1.74)	.2242
History of hypertension	0.52	(0.20, 1.37)	.1868
History of coronary artery disease	0.47	(0.19, 1.16)	.0998
Procedure characteristics			
Decade of procedure (1990s versus 1980s)	0.79	(0.31, 2.03)	.6188
Graft size*	0.70	(0.50, 0.96)	.0281

*Adjusted rate ratio for a 1 millimeter increase in graft size.

Considering the relatively poor patency rates of ABF grafting in young patients and those with smaller aortas, it is important to consider the therapeutic options. For those patients with claudication, risk factor modification, exercise, and pharmacologic therapy are options. A formal exercise-training program remains the primary nonpharmacologic treatment for claudication, as shown in more than 20 randomized trials.[16] Placebo-controlled studies comparing phosphodiesterase type 3 inhibitors, such as cilostazol, with pentoxifylline showed an improvement in walking distance by 40% to 50% with cilostazol.[17] Many young adults who are employed and otherwise active seek a more definitive (if not permanent) treatment for their disability. Aortoiliac angioplasty, with or without stenting, is the preferred treatment for patients with segmental aortoiliac disease. Patients with severe multifocal disease and occlu-

sions (TransAtlantic Inter-Society Consensus C and D patients[18]) are generally considered better candidates for surgical reconstruction. Nonetheless, reasonable results have been reported with aggressive applications of endovascular therapy in these patients.[19,20] Powell et al[21] found acceptable primary assisted patency rates of 72% at 3 years with a reintervention rate of 29% at a mean time of 10 ± 3 months in patients undergoing angioplasty and stenting of multisegment iliac occlusive disease. Their work revealed inferior patency rates in patients with external iliac disease, although neither of the groups was stratified according to age. Whenever feasible, it seems appropriate to attempt endovascular therapy in younger patients as the first line of intervention.

An important factor, not addressed in this retrospective study, is the functional outcome of ABF grafting in young adults. Although the bias of most vascular surgeons is that the quality of life of most patients is dramatically improved with ABF grafting, the findings in the literature have not been consistent. With a five-point questionnaire, Zannetti, L'Italien, and Cambria[22] found optimal functional results could be obtained in nondiabetic patients less than 70 years old operated on for intermittent claudication. They found most negative functional results came from those patients who had undergone infrainguinal reconstruction and were bothered by long-term lower extremity swelling. Schneider et al[23] retrospectively questioned 60 patients who had undergone ABF grafting and found that despite normalization of hemodynamics, the functional result was seriously limited by the patients' reported decrement in role function, health perception, and increased bodily pain after surgery. Although the average age in Schneider et al's[21] study was 61 ± 1 years, such diminished perceptions may be less prevalent in younger patients. It is reasonable to speculate that the functional and quality of life benefits in younger patients may be greater than in older, more debilitated patients.

As a retrospective study collected over two decades, this study has certain limitations. Endovascular therapy has evolved significantly during this interval, and some of the patients treated with aortobifemoral grafting early on in this series would now be treated with angioplasty with or without stenting. As mentioned previously, a complete evaluation of the utility of aortobifemoral surgery, particularly in young adults, would require a quality-of-life assessment. This is an important area for future investigation. Finally, the 39% rate lost to follow-up in this series merits some comment. In our experience, the rate lost to follow-up among ABF patients is among the highest of all the patients we treat. We believe this largely reflects the definitive and excellent results of this operation. Patients who are relieved of their symptoms and continue to do well gradually begin to space out return visits to beyond 18 months (the definition of lost to follow-up) only to return if problems arise.

The findings of this study thus pose a dilemma for vascular surgeons. ABF grafting has long been considered to be one of our most effective and durable vascular reconstructions. It has therefore been widely applied and would seem ideally suited for application in younger patients in whom a durable result is more desirable. The results of ABF in young adults in this series are certainly acceptable and offer appropriately selected patients greater potential benefit. These results, however, clearly show inferior patency rates and the need for subsequent interventions in younger patients. The potential impact of graft failure and the need for subsequent complex interventions must be considered—particularly in younger patients with a longer life expectancy. Exhaustion of all noninterventional and pertinent endovascular options is the appropriate first line option for young patients with severe aortoiliac occlusive disease.

We thank Ms Julie Lombara for assistance in data preparation.

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Submitted Sep 28, 2001; accepted Sep 3, 2002.