Brachial artery reconstruction for occlusive disease: A 12-year experience

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Objective: **Symptomatic arterial disease of the upper extremity is an uncommon problem. In this study, we evaluate our results with brachial artery reconstruction in patients who present with symptomatic atherosclerotic occlusive disease and compare this cohort's demographics with a similar group with lower extremity ischemia.**
Methods: **From 1986 to 1998, all patients presenting for upper extremity revascularization with chronic ischemia were prospectively entered into a vascular registry. Demographics, indications, outcomes, and patency were recorded. Patients presenting with embolus, pseudoaneurysm, or trauma were excluded. The Fisher exact and Student *t* tests were used to assess significance.**
Results: **Fifty-one (83%) bypass grafts were performed with autogenous conduit and the remainder with polytetrafluoroethylene. Indications included 18 (30%) patients with exertional arm pain, 35 (57%) with rest pain, and 8 (13%) with tissue loss. Twenty-five (45%) patients were male, 8 (14%) had diabetes, and 30 (54%) were smokers. The mean age was 58 years (range, 33-93). The operative mortality rate was 1.8%, and follow-up ranged from 1 to 140 months. Eight occlusions were identified, with six occurring early. Five of these were in women with a smoking history. Only one of the 26 reconstructions that did not cross a joint occluded, whereas bypass grafts that did cross a joint occluded more frequently. No other major complications were recognized.**
Conclusion: **Arm revascularization for ischemia can be performed with reasonable mortality and morbidity rates. These patients may represent a different subgroup of atherosclerotic disease than those with lower extremity involvement: they are more commonly women and smokers and less likely to be diabetic. (J Vasc Surg 2001;33:802-5.)**

Upper extremity ischemia that requires surgical intervention accounts for approximately 4% of all vascular surgical procedures.[1,2] Revascularization of the upper extremity was initially reported by Garrett et al in 1965.[3] Since that time, several authors have described their experience with this uncommon entity.[4-10] Compared with published data on lower extremity revascularization, no one large series of upper extremity reconstruction currently exists.

Upper extremity pathology differs markedly from the lower extremity. Though occlusive disease is seen in the upper extremity distal to the axillary artery, it is more common to have emboli, trauma (iatrogenic or noniatrogenic), collagen vascular disease, and thromboangiitis obliterans. Limb loss is rare. Surgical intervention is required much less because of the abundance of collateral circulation around the shoulder.

In this study, we evaluated our results with vascular reconstruction in patients who presented with symptomatic atherosclerotic occlusive disease encompassing the brachial artery. We compared them with all patients presenting for infrainguinal bypass graft in that same time period.

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METHODS

From 1986 to 1998, all patients presenting with both upper and lower extremity chronic ischemia to Albany Medical Center were prospectively entered into a vascular surgery registry. A retrospective review was undertaken to evaluate demographics, indications, outcomes, and patency in this cohort. Patients presenting with embolus, pseudoaneurysm, or trauma were excluded. For the upper extremity group, involvement of the brachial artery with occlusive disease was necessary for inclusion in this study. This occlusive disease was atherosclerotic in origin and was based on clinical setting, arteriographic findings, and gross pathology. Arteritis was never an etiology in this series based on clinical observation.

Patients with upper extremity symptoms were evaluated in our center with pulse volume recordings (PVRs) after we obtained an appropriate history from all patients and they underwent a physical examination. This included finger plethysmography in the setting of gangrene. Additionally, patients with exertional symptoms underwent PVR analysis after repetitive arm movement for any difference from their resting state. If the results were abnormal, individuals with rest pain or tissue loss underwent arteriography. Patients with exertional symptoms were observed with routine follow-up over several months. If this claudication-equivalent worsened or remained lifestyle limiting in the setting of abnormal PVR findings, arteriography was undertaken.

Autogenous conduit was preferred in limb-threatening

Table I. Demographics

	No.	*Percent*
Smoking	41	73
Coronary artery disease	28	50
Hypertension	26	46
Male	24	45
Diabetes	7	13
End-stage renal disease	4	7

Table II. Type of bypass graft performed

Bypass graft type	*Vein*	*PTFE*	*Total*
Brachial-brachial	23	1	24
Brachial-radial	5	0	5
Brachial-ulnar	4	0	4
Common carotid artery–brachial	9	5	14
Axillary-brachial	5	3	8
Subclavian-brachial	2	1	3
Axillary graft–brachial	1	0	1
Brachial graft–brachial	2	0	2

ischemia whenever available and of appropriate size match. All patients revascularized for an exertional indication had an autogenous conduit used. Greater saphenous vein was preferred, although arm vein is an acceptable alternative. All tunneling was preclavicular, not anatomic, and performed through a tunneling device placed subcutaneously. PVRs were repeated immediately postoperatively. All patients were seen in follow-up at regularly scheduled intervals with duplex scan and PVR evaluation of their grafts. After the initial comparison, all data were then restratified by risk factor analysis for further evaluation and comparison. Complications were tabulated, and statistical analysis was performed with the Fisher exact and Student *t* tests assuming significance for *P* less than .05. Life-table analysis was used in determining patency rates.

RESULTS

In the upper extremity, 61 bypass grafts were performed in 56 patients during the 12-year time period. The patients' mean age was 58 years (range, 33-93). Thirty-one (55.4%) of the patients were women. Demographics revealed 41 (73%) smokers, 28 (50%) patients with coronary artery disease, 26 (46%) patients with hypertension, 7 (13%) patients with diabetes, and 4 (7%) patients with end-stage renal disease. They are listed in Table I. Indications for bypass graft included exertional arm pain in 18 (30%), rest pain in 35 (57%), and tissue loss in 8 (13%). Fifty-one (83%) bypass grafts were performed with autogenous conduit and the remainder with polytetrafluoroethylene (PTFE). All procedures are listed in Table II. Follow-up averaged 23.2 ± 7.3 months (range, 1-140). There was one postoperative death, which was of cardiac origin, resulting in a 30-day operative mortality rate of 1.8%. There were six early occlusions (10%) and two late occlusions (3.3%). These are detailed in Table III. There was one postoperative wound infection (1.8%) and no limb loss. The late occlusions occurred in patients who had PTFE bypass grafts taken from across the shoulder joint to the brachial artery. One patient had an occlusion at 5 months, which was revised to a vein bypass graft. This bypass graft occluded in 1 day, and no further surgery was performed. The second patient had a bypass graft that occluded at 8 months. This was revised to a vein bypass graft and is still patent. Of the 56 patients who had upper extremity occlusive disease, 29 (48%) of them had lower extremity occlusive disease. This is in marked contrast to those patients with lower extremity occlusive disease; that is, only 1.5% of the nearly 4000 patients who underwent lower extremity bypass graft required upper extremity revascularization.

Life-table analysis revealed a patency of 90.5% for all bypass grafts at 1 year. Limb salvage was 100%. Looking at subgroups, we noticed all late occlusions occurred in PTFE bypass grafts across the shoulder. Seven of the eight occlusions in follow-up were seen in female smokers, and the eighth occurred in a male smoker. As others have identified, we found that bypass grafts that crossed a joint fared worse than those that did not.[11] There were 25 (96%) of 26 patent bypass grafts at 1 year that did not cross a joint. On the other hand, only 28 (80%) of 35 bypass grafts were patent in this same time period that did cross a joint ($P = .07$). Along the same lines, vein bypass grafts had a trend toward better patency, but no statistically significant difference; that is, 46 (90%) of 51 vein bypass grafts were patent at 1 year compared with 7 (70%) of 10 PTFE bypass grafts ($P = .09$). Patency rates are listed in Table IV.

We then compared the results of upper extremity revascularization with all lower extremity bypass grafts done in this same time period. No direct correlation can be made between these two groups. However, lower extremity reconstruction is more common to most involved in this surgery and therefore can be a reference point for comparison. This is summarized in Table V. There were 3886 patients in this second group. Males comprised 63.6%; patients with diabetes, 52%; and smokers, 36%. The mean age was 68 years. All of these were significantly different from that seen in the brachial bypass graft group. There was no difference in the use of prosthetic conduit. Statistically, the incidence of early occlusion (technical) occurred equally to that seen in the lower extremity group, whereas late occlusions were identified less often. Limb loss was not different statistically.

DISCUSSION

Disease of the brachial artery that requires surgical intervention is simultaneously not uncommon but far from an everyday occurrence. Because of the relative infrequency of this type of disease, authors of previously published reports have based their conclusions on relatively few numbers of cases.[4-7] This report is, to our knowledge, one of the largest reported series of these type of recon-

Table III. Occlusions

Original diagnosis	*Bypass*	*Graft*	*Redo procedure*	*When*	*Outcome*
Early					
Exertional arm pain	Brachial-brachial	Vein	Graft-brachial bypass with vein, thrombectomy	2 d	Patent at 4 mo
Exertional arm pain*	Common carotid to brachial	Vein	None	1 d	No further surgery
Exertional arm pain	Brachial-radial	Vein	Brachial-graft bypass with vein	1 d	Patent at 32 mo
Rest pain	Subclavian-brachial	Vein	Thrombectomy with vein patch	1 d	Died at 5 mo
Rest pain	Common carotid to brachial	Vein	Exc. missing valve	1 d	Patent at 16 mo
Rest pain	Common carotid to brachial	PTFE	Thrombectomy	7 d	Died at 3 mo, patent
Late					
Rest pain	Common carotid to brachial	PTFE	Vein bypass	8 mo	Patent at 4 mo
Rest pain*	Axillary-brachial	PTFE	Common carotid to brachial bypass w/vein	5 mo	Revised to vein bypass

*Same patient.

Table IV. Comparison of 1-year patency data

	No.	*Primary patency*	*Secondary patency*
All bypass grafts	61	87% (53)	98% (60)
Bypass grafts not crossing a joint	26	96% (25)	100% (26)
Bypass grafts crossing a joint	35	80% (28)	97% (34)
Vein bypass grafts	51	90% (46)	98% (50)
PTFE bypass grafts	10	70% (7)	80% (8)

Table V. Comparative demographics

	Brachial bypass graft	*Infrainguinal bypass graft*	P *value*
Male	44.6% (25)	63.6%	.002
Diabetic	13% (7)	52%	< .001
Smoker	73% (41)	36%	< .001
Mean age (y)	56	68	< .001
Prosthetic	17% (10)	20.4%	.51
Early occlusions	10% (6)	4.9%	.07
Late occlusions	3.3% (2)	11.6%	.04
30-day limb loss	0% (0)	1.8%	.29

structions; nevertheless, the absolute number of cases is not great enough to derive statistical significance from any one observation.

Compared with lower extremity vascular disease, the most striking difference is in the demographics of this patient group. There appeared to be an inordinately large percentage of female patients (55.4%). Patients presented at an early age (average, 58 years). In addition, diabetes was relatively less prevalent (13%). The incidence of hypertension, renal disease, and coronary arterial disease did not appear markedly different from that seen in lower extremity arterial disease groups. It was likely that patients presenting with symptomatic upper extremity disease also have significant synchronous lower extremity occlusive disease (48% in this series), whereas the converse is clearly not the case (1.5%). One presumes that this reflects a more aggressive form of disease that affects a wider swath of the arterial tree while presenting at a younger age.

The indications for surgery were frequently exertional arm pain (claudication equivalent) (30%). This prevalence in the context of a lower extremity series would clearly be excessive. Lower extremity claudication is generally treated conservatively because of the relatively benign nature of the disease and the incidence of postoperative morbidity and mortality with operative intervention. This is also true in most patients with upper extremity exertional pain. However, the low postoperative mortality (1.8%), morbidity (11.5%), and nonexistent limb loss rates would seem to justify operative intervention in the upper extremity in the face of exertional symptoms. This said, it is still true that most patients with such a degree of disease may be treated without operation.

Of the remaining patients in the reported group, relatively few presented with digital gangrene (13%). Of these eight patients, all had significant renal disease treated with

dialysis or transplant. These patients required the most distal reconstructions to the ulnar or radial arteries. In contradistinction to the results seen in lower extremity disease in the dialysis/transplant population, all patients with bypass grafts had improvement of their symptoms, survived the operation, and maintained bypass graft patency. Although a small group overall, these individuals may well need to be offered reconstruction more aggressively than is currently thought.

After upper extremity revascularization, this patient population had reasonable patency. Bypass graft performance in this group tended to follow some of the same principles seen in a typical lower extremity bypass graft series. Autogenous grafts performed somewhat better than PTFE grafts, although the numbers were too small to generate statistical significance. Bypass grafts that crossed a joint, especially the common carotid, subclavian, or axillary artery to brachial reconstructions, performed the most poorly in this series. We think that the tunneling of these bypass grafts in the region of the shoulder may be problematic, because it is difficult to tunnel anatomically, whereas the usual extra-anatomic tunnel along the anterior and superior aspects of the shoulder may predispose the graft to kinking with arm abduction or adduction. Fortunately, no limbs were lost in the patients who had bypass grafts that occluded. Offering a bypass graft that crosses a joint in the arm for exertional symptoms should be done somewhat cautiously because the results of surgery may not be ideal.

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CORRECTION

In: "Recommended standards for reports dealing with lower extremity ischemia: Revised version (Rutherford RB, Baker DJ, Ernst C, Johnston KW, Porter JM, Ahn S, Jones DN Jr. J Vasc Surg 1997;26:517-38).

The footnote to Tables IV (p. 526) and V (p. 528) contains an error. The last line of each foot note should indicate **division by column B rather than column C** and read as follows: Column G = $F \times \sqrt{\{(1 - [F/100]/B\}}$. The corresponding text on page 527 should then read as follows: (G) *Standard errors in percent* are calculated as F × square root of $\{(1 - (F/100))/B\}$, where F equals the cumulative patency rate in percent and **B** is the number at risk at the start of the interval.

Comment: This estimate of the standard error for both Life Table and Kaplan-Meier survival curves is consistent with that proposed by Peto et al (ref 28): standard error = $p\chi\sqrt{\{(1 - p)n)\}}$ where p = survival probability, 1 – p = probability of failure, and n = number at risk.