Choice of autogenous conduit for lower extremity vein graft revisions

Gregory J. Landry, MD, Gregory L. Moneta, MD, Lloyd M. Taylor, Jr, MD, James M. Edwards, MD, Richard A. Yeager, MD, and **John M. Porter, MD,** *Portland, Ore*

Background: **Surgical revision to repair stenosis is necessary in about 20% of lower extremity vein grafts (LEVGs). Alternate conduit, especially arm vein, is often necessary to achieve a policy of all-autogenous revisions. Although basilic vein harvest necessitates deep exposure in proximity to major nerves, it typically uses a large vein unaffected by prior intravenous lines and as such appears ideally suited for revisions in which a segmental interposition conduit is needed for revision within the graft or for extension to a more proximal inflow or distal outflow site. In this report, we describe our experience with the use of the basilic vein for LEVG revisions compared with other sources of autogenous conduit.**

Methods: **All patients who underwent LEVG were placed in a duplex scan surveillance program. LEVGs that developed a focal area of increased velocity or uniformly low velocities throughout the graft with appropriate lesions confirmed with angiography were candidates for revision. All patients who underwent graft revision with basilic vein segments from January 1, 1990, to September 1, 2001, were identified, and their courses were reviewed for subsequent adverse events (further revision or occlusion) and complications of harvest. These revisions were compared with revisions in which cephalic and saphenous vein were used.**

Results: **One hundred thirty basilic veins were used to revise 122 LEVGs. The mean follow-up period after revision was 28 ± 27 months. Ninety-three grafts (71%) remained patent with no further revision, and 37 grafts (29%) either needed additional revisions (22 grafts) or were occluded (15 grafts). Only four of these adverse events (11%) were directly attributed to the basilic vein segment. Ten of 43 grafts revised with cephalic vein (23%) were either revised or occluded, of which three were related to the cephalic vein segment (P = not significant, compared with basilic vein). Twenty-four of 81 grafts revised with saphenous vein (30%) were either revised or occluded, of which 11 were attributed to the saphenous vein segment ($P < .01$, compared with basilic vein). Two patients (1.5%) had complications from basilic vein harvest (one hematoma, one arterial injury). No neurologic injuries resulted from basilic vein harvest.**

Conclusion: **The basilic vein is a reliable and durable conduit when used to segmentally revise LEVGs. Stenoses rarely occur within interposed basilic vein segments, and excellent freedom from subsequent revision or occlusion is possible. We conclude the basilic vein can be safely harvested with minimal complications and is ideally suited for use as a short segment interposition graft for LEVG revision. (J Vasc Surg 2002;36:238-44.)**

The identification of suitable autogenous conduit for revision of lower extremity vein graft (LEVG) is frequently challenging. Options include residual ipsilateral or contralateral greater saphenous vein, lesser saphenous vein, or arm vein, including the cephalic and basilic veins. Because each of these conduit choices has associated advantages and disadvantages, a consensus for the ideal conduit has never been reached. Ideally, conduit should be easily harvested and of adequate caliber and quality, and the harvest itself should have a low incidence rate of complications. Perhaps most importantly, the conduit used for revision should have a small incidence rate of subsequent need for secondary revision or graft occlusion.

From the Division of Vascular Surgery, Department of Surgery, Oregon Health & Science University.

Competition of interest: nil.

Presented at the Sixteenth Annual Meeting of the Western Vascular Society, Santa Fe, NM, Sep 23-26, 2001.

Reprint requests: Gregory J. Landry, MD, Assistant Professor, Division of Vascular Surgery, Department of Surgery, Oregon Health & Science University, 3181 SW Sam Jackson Park Rd, Mail Code OP11, Portland, OR 97201-3098 (e-mail: landryg@ohsu.edu).

0741-5214/2002/$35.00 + 0 **24/6/125024**
doi:10.1067/mva.2002.125024

Patients who undergo vascular surgical procedures have frequently undergone saphenous vein removal for vascular and cardiac procedures. Arm vein harvest is, therefore, an essential component of the armamentarium of vascular surgeons involved in limb salvage surgery and dedicated to an all-autogenous policy for infrainguinal arterial reconstruction. Although the cephalic vein is typically more superficial and easily harvested, it is frequently of small caliber and has often been used for intravenous cannulation. The basilic vein, because of its deeper location and proximity to important nerve and arterial structures, is rarely used as an intravenous site and is typically a large caliber vein. Despite its relatively short length, it should be an ideal conduit for LEVG revisions necessitating short segments of venous conduit. No available data exist, however, quantifying the results of vein graft revisions with basilic vein conduits. The authors' experience with the basilic vein for LEVG revisions forms the basis of this report.

METHODS

All patients who underwent LEVG at either the Oregon Health & Science University or Portland Veteran's Administration Medical Center were prospectively entered into a postoperative duplex ultrasound scan–based vein

graft surveillance protocol that included history and physical examination, ankle/brachial index determination, and duplex scan examination of the entire graft, including the native inflow and outflow vessels. Patients were evaluated during their initial hospitalization, every 3 months for the first year after the initial bypass or revision procedure, and every 6 months thereafter. All duplex scan examinations were performed by certified vascular technologists.

The criteria for identification of a graft at risk included a focal peak systolic velocity (PSV) within the graft or in the inflow or outflow sites greater than 200 cm/s, a prestenotic to intrastenotic PSV ratio greater than 3.0, uniformly low PSV less than 45 cm/s throughout the entire graft, an interval decrease in the ankle/brachial index greater than 0.2, or a significant change in clinical status. Patients with duplex scan–detected graft abnormalities underwent arteriography before revision.[1] Lesions with >50% diameter stenosis with arteriogram were repaired. The revisions were performed as soon as possible after the identification of a suspicious lesion.

Prerevision duplex scan vein mapping was routinely performed to identify available conduit for revision. Examinations were performed with a 5-MHz to 10-MHz probe, and vein location was marked on the skin with an indelible marker. Useable vein length and diameters were recorded. A vein segment was believed to be potentially useable if no portion of the vein was less than 2 mm in diameter and ideally not less than 3 mm in diameter. The basilic vein was typically mapped from the axilla to the antecubital fossa unless a dominant branch continued on to the forearm. The cephalic vein was mapped from the deltopectoral groove to the antecubital fossa unless a dominant branch continued on to the forearm. Although most patients had the veins of both arms mapped, occasionally the mapping was limited to one arm if sufficient vein for the proposed procedure was identified. This was done at the discretion of the vascular laboratory technologists in consultation with the surgical team.

Basilic vein harvest was performed through a continuous incision at the premarked site. Side branches were ligated with silk sutures. Veins were prepared with distention with either chilled autologous blood (60 mL) mixed with 3000 U heparin, 30 mg papaverine hydrochloride, and 100 mg lidocaine (Oregon Health & Science University) or with chilled heparinized 0.9% normal saline solution (Portland Veteran's Administration Medical Center). Arm vein harvest sites were closed with running absorbable sutures in multiple layers. Closed suction drains were not routinely used. The arms were wrapped with an elastic compression dressing perioperatively to limit perioperative ecchymosis and swelling.

Several types of revision procedures were performed depending on the nature and location of the lesions. *Interposition vein grafts* involved placement of a new vein segment within a graft and not the proximal or distal anastomoses. *Proximal revisions* and *distal extensions* involved the creation of a new anastomosis to the native arterial inflow or outflow with a new vein segment. *Vein patch angioplasty* involved placement of a vein patch over a focal stenosis rather than placement of a new segment of vein. The type of revision procedure performed was left to the discretion of the operating surgeon. Revisions in which a only a vein patch was placed were excluded because our interest was primarily in determining the characteristics of segmental vein grafts with different conduits and it was believed that the results of a vein patch are less reliant on the source of vein used.

Table I. Revision conduits and types of revisions performed

	Conduit		
Type of revision	*Basilic*	*Cephalic*	*Saphenous*
Vein patch angioplasty	19	6	30
Proximal revision	50	17	35
Interposition	41	8	22
Distal extension	39	22	24
Total	149	53	111

Patient data were entered into a confidential computerized database (Corel7 Paradox, version 8.0, Borland International, Scotts Valley, Calif) and included demographic data, the date, conduit, inflow and outflow, and indication for the initial operation, duplex scan surveillance data, and date, conduit, lesion sites, and procedure performed for revision procedures. Dates of graft occlusion also were recorded. The Kaplan-Meier method with log-rank analysis was used to estimate freedom from subsequent adverse events after revisions with basilic vein. *Adverse events* were defined as either graft occlusion or the need for subsequent secondary revision. When a revision was necessary or an occlusion occurred, records were reviewed to determine whether the adverse event was caused by the interposition segment that had been placed during the revision or by remote lesions in either the original graft or in the native arterial inflow or outflow vessels. These data were compared with the same data obtained from LEVG revised with cephalic and saphenous vein segments. Statistical analysis was performed with the χ^2 test for frequencies and proportions and the *t* distribution for comparison of means (JMP, version 3.1.5., SAS Institute, Cary, NC).

RESULTS

Between January 1, 1990, and September 1, 2001, 375 LEVG revisions were performed. Basilic vein was harvested and used in 149 of these revisions (Table I). In 19 revisions, the basilic vein was used to perform a vein patch over a focal stenosis, and these revisions were excluded from further analysis. In 130 revisions, an interposition segment of basilic vein was placed either within the graft or from the graft to a new native inflow or outflow site (50 proximal revisions, 41 interposition grafts, 39 distal extensions). The mean length of time between the original operation and the revision procedure was 21.9 ± 32.2 months (mean ± standard deviation [SD]; median, 8.1 months). The mean

Table II. Freedom from subsequent adverse events (revision or occlusion) after graft revision

Interval (mo)	*Cumulative freedom*	*Interval freedom*	*SE*	*Adverse events*	*Withdrawn*	*At risk*
Grafts revised with basilic vein						
0-6	0.8483	0.8483	0.0341	17	29	130
6-12	0.7810	0.9327	0.0410	6	14	84
12-24	0.6665	0.8855	0.0515	8	15	64
24-36	0.5896	0.9231	0.0583	4	12	41
36-48	0.5403	0.9507	0.0630	2	6	25
48-60	0.5403	1.0000	0.0630	0	7	17
Graft revised with cephalic vein						
0-6	0.9523	0.9523	0.0332	2	13	47
6-12	0.7901	0.8378	0.0721	5	7	32
12-24	0.7045	0.9144	0.0860	2	4	20
24-36	0.6405	0.9360	0.0992	1	3	14
Grafts revised with saphenous vein						
0-6	0.8648	0.8648	0.0399	10	11	81
6-12	0.8048	0.9400	0.0471	4	6	60
12-24	0.7001	0.8953	0.0573	6	11	50
24-36	0.6204	0.9203	0.0669	3	10	33
36-48	0.6204	1.0000	0.0669	0	5	20
48-60	0.5761	0.9557	0.0754	1	2	15

P = NS with log-rank analysis at all time intervals between grafts revised with basilic, cephalic, and saphenous veins.

follow-up period after the revision with basilic vein was 27.5 ± 27.2 months (mean ± SD; median, 17.8 months).

During the same time period, 53 LEVG revisions were performed with a segment of cephalic vein, of which six were vein patches that were excluded from further analysis. Forty-seven revisions involved placement of a segment of cephalic vein (17 proximal revisions, eight interposition grafts, and 22 distal extensions). The mean length of time between the original operation and revision was 25.7 ± 39.3 months (mean ± SD; median, 11.0 months). The mean follow-up period after the revision with cephalic vein was 26.6 ± 28.4 months (mean ± SD; median, 13.0 months). One hundred eleven revisions were performed with a segment of saphenous vein, of which 30 were vein patches and excluded from further analysis. Eighty-one revisions involved placement of a saphenous vein segment (35 proximal revisions, 22 interposition grafts, and 24 distal extensions). The mean time between the original operation and revision was 22.8 ± 26.4 months (mean ± SD; median, 12.8 months). The mean follow-up period after revision was 38.0 ± 31.2 months (mean ± SD; median, 30.1 months; $P < .05$, compared with basilic and cephalic vein).

Preoperative duplex scan vein mapping. The results of duplex scan vein mapping procedures in 296 extremities were reviewed. Useable basilic vein was identified in 275 of 296 extremities mapped (92.9%). In contrast, a useable segment of cephalic vein was identified in 224 extremities (75.7%; $P < .001$, compared with basilic vein). Maximal and minimal vein diameters were recorded. Maximal and minimal basilic vein diameters were 5.7 ± 1.6 mm and 3.3 ± 0.8 mm, respectively. Maximal and minimal cephalic vein diameters were 4.1 ± 1.2 mm and 2.8 ± 0.8 mm, respectively ($P < .001$, compared with basilic vein). The length of available basilic vein was 23.5 ± 8.1 cm, compared with 32.6 ± 11.6 cm of available cephalic vein ($P < .001$).

Freedom from adverse events. Grafts revised with an interposition segment of basilic, cephalic, and saphenous vein were evaluated for the occurrence of a subsequent adverse event (graft occlusion or the need for subsequent revision). These data are listed in Table II. At 1, 3, and 5 years after revision, 78.1%, 59.0%, and 54.0%, respectively, of grafts revised with basilic vein were free of a subsequent adverse event. Of the 130 LEVGs revised with basilic vein, 15 (12%) went on to occlude, 22 (17%) needed subsequent revisions, and 93 (71%) remained patent without the need for further revisions.

In 47 LEVGs revised with a cephalic vein segment, freedom from subsequent adverse events at 1 and 3 years was 79.0% and 64.1%, respectively (P = not significant [NS], compared with basilic vein). In 81 LEVGs revised with a segment of either ipsilateral or contralateral saphenous vein, freedom from adverse events at 1, 3, and 5 years was 80.4%, 65.0%, and 57.6%, respectively (P = NS, compared with basilic and cephalic vein) (Fig).

Cause of adverse events in revised lower extremity vein graft (Table III). In the 22 grafts revised with basilic vein segments that necessitated subsequent revision, nine (41%) involved a different area in the original graft remote from the basilic vein segment and seven (32%) involved progression of native arterial disease in either the inflow or outflow vessels. Two secondary revisions (9%) were at the site of an anastomosis between the basilic vein segment and

Table III. Causes of graft occlusion and need for revision in LEVFs revised with basilic, cephalic, and saphenous vein

	Basilic (n = 130)	*Cephalic (n = 47)*	*Saphenous (n = 81)*
Cause of occlusion			
Inflow occlusion	4	–	–
Previously revised portion of graft	–	–	–
New portion of graft or anastomosis	4	–	–
Outflow occlusion	3	1	1
Unknown	4	1	1
Cause for revision			
Inflow stenosis	4	1	2
Previously revised portion of graft	4	3	11
New portion of graft or anastomosis	11	3	8
Outflow stenosis	3	1	1
Total occlusions or revisions	37	10	24

either the native artery or the site of a venovenostomy. In four secondary revisions (18%), the lesion was within the previously placed basilic vein segment.

The reason for graft occlusion in the 15 grafts revised with basilic vein that subsequently occluded was believed to be causes other than the basilic vein conduit in 11 cases. In four cases, proximal prosthetic inflow (two aortofemoral limbs and two femoral-femoral grafts) occlusion coincided with the LEVG occlusion. In three cases, grafts were to distal tibial or pedal arteries with poor outflow and no further distal targets for extension. In four cases, the original conduit was noted to be of poor quality and additional stenoses within the graft not associated with the basilic vein had been identified. One of these patients refused further revision, one did not have any further conduit for revision, one was scheduled for revision but the graft occluded before revision, and one was followed with subsequent occlusion.

In four cases in which a graft revised with basilic vein occluded, the cause for occlusion could not be determined. In two cases, the patients did not return for follow-up between the time of revision and the time of occlusion, which occurred 19 and 27 months after the revisions. In two cases, the grafts occluded for unknown reasons despite adequate follow-up.

No occlusions were known to be directly related to problems with the basilic vein segment. Four secondary revisions were directly related to problems with the basilic vein segment. Anastomotic lesions were not included because the cause of anastomotic lesions may be related to factors other than the quality of conduit. With exclusion of the four occlusions of undetermined cause, only four of 126 graft revisions with basilic vein (3.2%) ever had additional problems related to the basilic vein. In the 37 LEVGs revised with basilic vein segments that underwent subsequent revision or occluded, the basilic vein was identified as the cause of the problem in four (11%), 29 were caused by problems in other areas of the graft or native arteries (78%), and four were from unknown causes (11%).

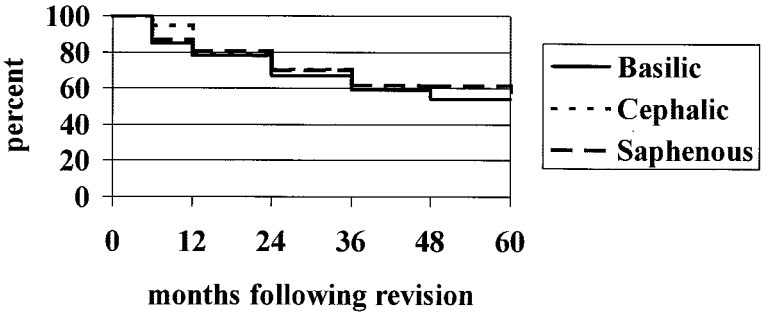
Ten grafts revised with cephalic vein had adverse events at 3 years of follow-up (two occlusions, eight revisions). One occlusion was believed to be caused by poor outflow in a graft to the dorsalis pedis artery. The cause of the other occlusion was undetermined. Three of the eight revisions involved lesions within the cephalic vein conduit, two were at one of the cephalic vein graft anastomoses, and three were at other areas in the graft or native vessels. Thus, with exclusion of the occlusion of undetermined cause, three of 46 cephalic vein segments (6.5%) had subsequent adverse events (P = NS, compared with basilic vein at 3 years). In the 10 LEVGs revised with cephalic vein segments that had subsequent adverse events, three were caused by problems with the cephalic vein segment (30%), six were caused by problems in other areas of the graft or native arteries (60%), and one was of unknown cause (10%; P = NS, in comparison with revisions performed with basilic vein).

Twenty-four grafts revised with a segment of saphenous vein had adverse events at 5 years (two occlusions, 22 revisions). One occlusion was of undetermined nature. One was caused by poor distal outflow in a graft to the dorsalis pedis artery. In 22 revisions, 11 were in the saphenous vein segment, three at an anastomosis, five in a different portion of the graft, and three in the native arterial inflow or outflow. Thus, with exclusion of the occlusion of undetermined cause, 11 of 80 grafts revised with saphenous vein (13.8%) had subsequent adverse events related to the saphenous vein (P = .01, compared with basilic vein). In the 24 grafts with subsequent secondary revisions or occlusions, 11 were believed to be caused by problems with the saphenous vein segment (46%), 12 were caused by problems in other areas of the graft or native arteries (50%), and one was from an unknown cause (4%; P = .005, in comparison with grafts revised with basilic vein).

Complications of vein harvest. In 130 basilic vein harvests, two complications occurred, for a 1.5% complication rate. One postoperative hematoma necessitated operative evacuation. One brachial artery injury occurred during the harvest and was recognized and repaired. No neurologic injuries or wound infections occurred as a result of basilic vein harvest. Two wound hematomas necessitating surgical drainage resulted after 47 cephalic vein harvests, for a 4.3% complication rate. Four complications occurred after 81 saphenous vein harvests (4.9% complication rate), including two hematomas, one infection, and one incisional dehiscence with subcutaneous fat necrosis. No statistical difference in the rate of harvest complications was present between the conduits examined.

DISCUSSION

The importance of the use of arm veins in lower extremity bypass surgery has long been recognized. When the saphenous vein is not available for bypass procedures, excellent patency can be achieved with bypasses composed of either a single segment or spliced arm veins.[2-4] With ap-



Freedom from occlusion or additional revision after graft revision.

proximately 20% of LEVGs ultimately needing operative revision because of stenoses, the use of alternate vein becomes essential to maintain an all-autogenous graft. Although contralateral saphenous vein may be available, it has frequently been removed for other operative procedures (eg, coronary bypass or other lower extremity bypass procedures), with residual segments of both ipsilateral and contralateral saphenous vein frequently being small or sclerotic. In addition, removal of the contralateral saphenous vein in the presence of contralateral arterial occlusive disease may be undesirable. The lesser saphenous vein is occasionally an available option. The lesser saphenous vein, however, is difficult to harvest with the patient supine, and harvesting from the prone position typically necessitates repositioning and reprepping for the subsequent revision procedure. The authors perform LEVG revision with lesser saphenous vein infrequently.

The use of arm vein is a critical element of an all-autogenous revision policy. The cephalic vein is easily harvested from its lateral, subcutaneous position. Basilic vein harvest is less straightforward because of its deeper medial position in proximity to major nerve and vascular structures. Both are excellent sources of alternate conduit in LEVG revisions; however, the basilic vein may have some modest advantages over cephalic vein when used as a short segment interposition graft. Because of its easy access, the cephalic vein is frequently used as a site of intravenous cannulation. A recent study noted a four-fold increased incidence rate of venous thrombosis in cephalic veins cannulated for peripherally inserted central catheters compared with basilic veins.[5]

In this study, the basilic vein was more reliably identified on preoperative duplex scan vein mapping (93% versus 76%) and was also noted to be larger in diameter. The optimal conduit diameter is unclear; however, it is likely that smaller caliber conduits are associated with inferior patency. In a multivariate analysis, Idu and associates[6] found vein diameter less than 3.5 mm to be the only independent risk factor for the subsequent development of graft stenosis. The larger caliber of the basilic vein did not adversely affect patency. Although of theoretic concern, size mismatch between the basilic vein and other areas of the graft or the native, particularly tibial, vessels is frequently encountered in composite vein and revised grafts.

We frequently repair focal (<1 cm length) stenoses with a vein patch. These revisions were not included in this analysis because the source of conduit is less likely to be important in these cases. With its shorter length compared with the cephalic vein, the basilic vein appears ideally suited to revisions in which a short segment of autogenous conduit is needed (eg, single stenoses >1 cm in length or multiple stenoses in close proximity). In most revision procedures, the length of the basilic vein is adequate for use as an interposition segment. In these situations, it may be preferable to save adequately sized cephalic vein for a situation in which a longer venous segment is necessary.

The cephalic and basilic veins are used increasingly to create autogenous fistulas for hemodialysis. Although not directly comparable with the topic of this study, Hakaim, Nalbandian, and Scott[7] did note superior maturation of transposed basilic vein fistulas (0% nonmaturation) compared with upper arm brachiocephalic fistulas (27% nonmaturation) and wrist radiocephalic fistulas (70% nonmaturation). The 18-month patency rates of upper arm brachiocephalic fistulas (78%) and transposed basilic vein fistulas (79%) were equal, with each being markedly better than that of radiocephalic fistulas (33%). The reason for the poor performance of the lower arm cephalic vein is unclear.

Ideally, after a LEVG is revised, it would be free of the need for further revisions and free of the risk of subsequent occlusion. Clearly, however, these adverse events do occur, and although excellent assisted primary patency can be achieved in revised grafts,[8-10] no graft is reliably immune from subsequent problems. In this study, the life-table incidence rate of subsequent adverse events was equal regardless of the conduit used—basilic, cephalic, or saphenous vein. The incidence rate of either additional revision or graft occlusion at 1, 2, and 3 years was 78%, 79% and 80%; 67%, 70% and 70%; and 59%, 64%, and 62%, respectively, with the use of basilic, cephalic, and saphenous vein conduit. These results are not directly comparable because the choice of conduit was not randomized but rather left to the discretion of the surgeon.

Despite the fact that these adverse events do occur, closer examination reveals that they are rarely related to the basilic vein segment. We have previously shown that when secondary revisions are necessary, the site of prior revision is involved in approximately half.[8] In this series, only four of

22 secondary revisions involved the basilic vein conduit. In cases in which the cause of occlusion could be identified, none were directly related to the basilic vein, although admittedly, an element of conjecture is introduced in assigning reasons for occlusion. At 5 years of follow-up, only approximately 3% of basilic vein segments were known to cause any further adverse events. Cephalic vein interposition grafts had a 3-year incidence rate of adverse events of 6.5%, and saphenous vein segments had a 5-year incidence rate of adverse events of approximately 14%. Thus, for all types of revision conduit, the subsequent patency or need for revision appears to be determined primarily by the either the quality of the initial bypass graft conduit or by progression of disease in the native arterial inflow or outflow.

The harvest of basilic vein is associated with surprisingly few complications. As opposed to leg incisions, which have a notoriously high complication rate of up to 20%,[11] complications of arm vein harvest are rare. Our practice is to snugly wrap the arm with an elastic bandage after harvest. Although ecchymosis is common, infection and hematoma seldom occur. In this series, only one hematoma necessitating surgical evacuation occurred in 130 basilic vein harvests, and no wound infections occurred. The proximity of the basilic vein to important neurologic and vascular structures is also a concern. However, only one arterial injury, which was corrected, and no long-term neurologic injuries resulted from basilic vein harvest.

That the basilic vein is superior to cephalic vein or other alternate conduit cannot be definitively concluded from these data. A randomized trial would be necessary to further delineate this. However, it does appear that the basilic vein is at least comparable with other autogenous conduit sources. Once used for an LEVG revision, the basilic vein rarely is the cause of subsequent graft occlusion or the need for further revision. Despite its less accessible anatomic location, with meticulous technique, it can be safely harvested. Its length and diameter make it ideally suited for short segment graft interpositions, leaving longer venous conduits available for other potential uses needing longer segments of autogenous conduit.

REFERENCES

1. Landry GJ, Moneta GL, Taylor LM, McLafferty RB, Edwards JM, Yeager RA, et al. Duplex scanning alone is not sufficient imaging prior to secondary procedures following lower extremity reversed vein graft bypasses. J Vasc Surg 1999;29:270-81.
2. Gentile AT, Lee RW, Moneta GL, Taylor LM Jr, Edwards JM, Porter JM. Results of bypass to the popliteal and tibial arteries with alternative sources of autogenous vein. J Vasc Surg 1996;23:272-80.
3. Chang BB, Darling RC III, Bock DEM, Shah DM, Leather RP. The use of spliced vein bypass for infrainguinal arterial reconstruction. J Vasc Surg 1995;21:403-12.
4. Holzenbein TJ, Pomposelli FB Jr, Miller A, Contreras MA, Gibbons GW, Campbell DR, et al. Results of a policy with arm veins used as a first alternative to an unavailable ipsilateral greater saphenous vein for infrainguinal bypass. J Vasc Surg 1996;23:130-40.
5. Allen AW, Megargell JL, Brown DB, Lynch FC, Singh H, Singh Y, et al. Venous thrombosis associated with the placement of peripherally inserted central catheters. J Vasc Intervent Radiol 2000;11:1309-14.
6. Idu MM, Buth J, Hop WCJ, Cuypers P, van de Pavoordt EDWM, Tordoir JMH. Factors influencing the development of vein-graft stenosis and their significance for clinical management. Eur J Vasc Endovasc Surg 1999;17:15-21.
7. Hakaim AG, Nalbandian M, Scott T. Superior maturation and patency of primary brachiocephalic and transposed basilic vein arteriovenous fistulae in patients with diabetes. J Vasc Surg 1998;27:154-7.
8. Landry GJ, Moneta GL, Taylor LM Jr, Edwards JM, Yeager RA, Porter JM. Patency and characteristics of lower extremity vein grafts requiring multiple revisions. J Vasc Surg 2000;32:23-31.
9. Avino AJ, Bandyk DF, Gonsalves AJ, Johnson BL, Black TJ, Zwiebel BR, et al. Surgical and endovascular intervention for infrainguinal vein graft stenosis. J Vasc Surg 1999;29:60-70.
10. Idu MM, Blankensteyn JD, de Gier P, Truyen E, Buth J. Impact of a color-flow duplex surveillance program on infrainguinal vein graft patency. A five year experience. J Vasc Surg 1993;17:42-52.
11. Nicoloff AD, Taylor LM Jr, McLafferty RB, Moneta GL, Porter JM. Patient recovery after infrainguinal bypass grafting for limb salvage. J Vasc Surg 1998;27:256-66.

Submitted Oct 3, 2001; accepted Dec 7, 2001.

DISCUSSION

Dr Mark Nehler (Denver, Colo). Dr Landry and colleagues from Oregon continue their extensive investigation of graft surveillance and operative revision of threatened reversed infrainguinal bypass grafts. The present discussion focuses on the use of the basilic vein for interposition graft revision to treat short-segment unifocal or multifocal graft/inflow/outflow lesions. As expected from this group, the results are excellent. Not surprisingly, basilic veins are larger and shorter than cephalic veins on preoperative duplex. Rare harvest complications are noted with basilic veins (I was actually responsible for the lone arterial injury). Assisted primary patency was 72% at a mean follow-up of over 2 years. Life table determined freedom from adverse events (occlusion or need for further revision) was 59% and 54% at 3 and 5 years, which was no different from cephalic or saphenous interposition graft revisions.

I have a few technical questions. The previous report from OHSU detailing surgical results in the revision of all threatened vein grafts demonstrated assisted primary patency rates of 90-plus percent at 3 and 5 years. Why is the current assisted primary patency rate with basilic vein interpositions only 72% at a little over 2 years? The very proximal basilic vein can have large diameter branches that are of relatively short length, making placement of standard silk ties difficult to avoid narrowing and prevent the tie from coming off with distension. Do the authors find the need to suture ligate these branches? Due to the obvious size mismatch between tibial arteries and the basilic vein interposition graft, how many times was this situation encountered? Did this necessitate a longer arteriotomy to match to the vein size and a greater degree of distal artery exposure and therefore greater incision? As many patients require assist devices to resume early postoperative ambulation, do the authors have a sense of whether the arm harvest incisions interfered with patients' ability to use a walker postoperatively? Does the large caliber of the interposition basilic vein segments change the interpretation of subsequent duplex exami-

nations with regard to lower velocities? Were unusable basilic vein segments on duplex determined due to size criteria or lack of visualization?

Finally, I have several philosophical questions. The authors have performed and reported extensively on graft surveillance and graft revision. In addition, the authors have pointed out the extensive morbidity associated with limb salvage surgery, particularly regarding wound complications. Despite the minimal morbidity associated with arm vein harvest, the morbidity associated with redo infrainguinal exposures is not minimal. This is important, as these are patients with asymptomatic graft lesions frequently nearing the end of life. Do the authors consider these issues in the management of these patients? For example, would a patient with persistent postoperative lymphedema and a distal graft lesion be considered for interventional therapy to avoid a reoperative wound problem accepting an inferior intermediate-term patency result? Conversely, is a patient who undergoes an operative revision of a threatened bypass and dies 6 months later with a patent graft and an operative wound that has yet to heal considered a success or a failure? Finally, despite the traditional focus on graft patency and limb salvage, is it really always the best plan to maximize these two parameters in a population with much lower intermediate-term survival when doing so frequently has significant morbidity? I would like to thank the authors for providing the manuscript in a timely fashion and the Society for the opportunity to discuss this important issue.

Dr Gregory J. Landry. Thank you, Dr Nehler, for your thoughtful discussion. During the time that Mark was in Oregon he set up the original database to examine revised vein grafts, and this has been the impetus for much of our subsequent work.

In response to your first question, in this study a different endpoint was evaluated than in previous studies examining revised lower-extremity vein grafts. In previous work, we have reported assisted primary patency of revised lower-extremity vein grafts, and this is, as you correctly point out, approximately 90% at 5 years, with the starting point being the date of the original operation. In the current study, we examined freedom from the need for revision or occlusion after the initial graft revision, so the starting point is the date of the original graft revision rather than the original operation, and this explains why the 5-year assisted patency rate is lower.

The majority of branches arising from the basilic vein can be ligated with silk ligatures. Great care must be taken to place the ligatures at least 1 mm away from the basilic vein to prevent dimpling when the vein is distended. Occasionally the basilic vein will have broad-based branches which are better managed with a running polypropylene suture rather than with a silk ligature.

The basilic vein is almost always significantly larger than the tibial artery. Approximately 20% of graft revisions involve placement of an extension graft to a distal tibial artery. The size mismatch does not appear to affect patency, and no special measures are required to manage the size mismatch.

We have been pleasantly surprised by the minimal morbidity caused by arm vein harvest incisions. It is extremely rare for patients to complain about their arm incisions compared with the frequent complaints about leg incision discomfort. The arm incisions do not appear to interfere with postoperative rehabilitation. The duplex findings in the basilic vein segments were not examined in this study. Basilic veins were determined to be unusable if they were not able to be located or if they were extremely small, typically less than 2 mm in diameter.

The last questions address what is perhaps the most important current question in lower-extremity bypass surgery, namely, patient outcomes and quality of life. Clearly there are patients who meet the criteria for graft revision who have severe comorbidities or decreased life expectancy in whom graft revision is not in their best interest. This is clearly a matter of judgment on the part of the physician as well as communication with the patient, family, and referring physician and is one of the greatest challenges that we face. While patency and limb salvage are very tangible outcome points that we should always seek to maximize, they should not be at the expense of patient quality of life. This will be particularly important as vascular surgeons treat an increasingly aging population.