Outcome after autogenous brachial-axillary translocated superficial femoropopliteal vein hemodialysis access

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Objective: **The optimal configuration for patients with "complex" or "tertiary" hemodialysis access needs remains undefined. This study was designed to examine the utility of the autogenous brachial-axillary translocated superficial femoropopliteal vein access (SFV ACCESS) in this subset of patients.**

Methods: **Patients presenting for permanent hemodialysis access without a suitable upper extremity vein for autogenous access identified by duplex ultrasound mapping and those with repeated prosthetic access failures were considered candidates for SFV ACCESS. Ankle-brachial indices were obtained, and duplex scanning of the superficial femoropopliteal and saphenous veins was performed. Patients deemed candidates for SFV ACCESS also underwent preoperative upper extremity arteriography and venography. A retrospective review of the complete medical record was performed, and a follow-up telephone or personal interview was conducted.**

Results: **Thirty patients (mean age ± SD, 54 ± 15 years; male, 33%; white, 37%; with diabetes, 50%; obese, 21%) underwent SFV ACCESS among approximately 650 access-related open surgical procedures during the study period. The patients had been receiving dialysis for 4 ± 5 years (range, 0-24 years), and had 3 ± 3 (range, 0-17) prior permanent accesses, whereas 90% were actively dialyzed through tunneled catheters. In-hospital 30-day mortality was 3%, and the hospital length of stay was 7 ± 7 days. Fifty-seven percent of the patients experienced some type of perioperative complication, and 38% required a remedial surgical procedure. Hand ischemia developed in 43% of the patients (severity grade: 1, 10%; 2, 7%; 3, 27%), and a distal revascularization, interval ligation was performed in all those with grade 3 ischemia. Thigh wound complications or hematomas developed in 23% of the patients, and arm wound complications or hematomas developed in 17%. The incidence of thigh wound complications was significantly greater (57% vs 9%; $P = .03$) in obese patients, but the other perioperative complications analyzed could not be predicted on the basis of age, gender, or comorbid conditions. The SFV ACCESS was cannulated 7 ± 1 weeks postoperatively. The primary, primary assisted, and secondary patency rates were 96% ± 4%, 100% ± 0%, and 100% ± 0%, respectively, at 6 months; 79% ± 8%, 91% ± 6%, and 100% ± 0%, respectively, at 12 months; and 67% ± 13%, 86% ± 9%, and 100% ± 0%, respectively, at 18 months (life table analysis; % ± SE).**

Conclusions: **The intermediate term functional patency rate after SFV ACCESS is excellent, although the magnitude of the procedure and the complication rate are significant. SFV ACCESS should only be considered in patients with limited access options. (J Vasc Surg 2004;40:311-8.)**

The National Kidney Foundation Clinical guidelines for vascular access (Dialysis Outcome and Quality Initiative) have helped define the algorithms for patients requiring permanent hemodialysis access and have emphasized the benefits of autogenous configurations.[1] The Dialysis Outcome and Quality Initiative recommends the autogenous radiocephalic and brachiocephalic accesses as their first two choices, and state that the third option should be either an autogenous brachiobasilic or prosthetic access. The optimal access configuration in patients with inadequate peripheral veins for autogenous access and those with multiple previous prosthetic failures remains undefined. This subset of patients with "complex" or "tertiary" access problems poses a difficult challenge in terms of maintaining sufficient access to ensure adequate dialysis while minimizing access-related complications. Unfortunately, this subset of patients will likely increase, given the expanding population of patients with end-stage renal disease (ESRD) and their improved life expectancy. Indeed, the United States Renal Data System reported that there were approximately 250,000 patients receiving hemodialysis in 2000, including 94,000 new patients, while the mean life expectancy for patients with ESRD between 50 and 54 years of age is greater than 5 years.[2] We have previously described using the superficial femoropopliteal vein to construct an autogenous brachial-axillary access (SFV ACCESS) in a patient with limited autogenous options considered a poor candi-

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Competition of interest: none.

Presented at Twenty-eighth Annual Meeting of the Southern Association for Vascular Surgery, Rio Grande, Puerto Rico, Jan 14-17, 2004.

Additional material for this article may be found online at www.mosby.com/jvs.

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0741-5214/$30.00

doi:10.1016/j.jvs.2004.04.018

date for a prosthetic access.[3] This study was designed to examine the utility of the SFV ACCESS in a larger series of patients with complex hemodialysis access needs.

METHODS

Experimental design. Patients who underwent SFV ACCESS between November 1998 and December 2003 were identified from the vascular registry in the Division of Vascular and Endovascular Therapy at the University of Florida College of Medicine. A retrospective review of the outpatient clinic and the hospital medical records, including the admitting history and physical examination, the inpatient progress notes, the operative report, and the noninvasive and invasive imaging studies was performed, and a comprehensive database was generated. In addition, the study patients or their respective dialysis units were interviewed either in person or by telephone to confirm the current status of the access and to identify any additional problems.

Preoperative evaluation. Patients referred to the vascular surgery service for permanent access were evaluated with our previously published algorithm designed to optimize the use of autogenous access.[4] In brief, patients underwent upper extremity arterial and venous noninvasive vascular laboratory testing as the initial step. The arterial studies included pressure measurements and waveform analyses of the brachial, radial, and ulnar arteries, in addition to diameter measurements of the brachial and radial vessels at the elbow and wrist, respectively. The venous noninasive imaging included assessment of both the diameter and quality of the cephalic and basilic veins from the wrist to the axilla, and interrogation of the axillary and subclavian veins, to rule out thromboses. The criteria used to determine whether the artery and vein were suitable for constructing an autogenous access included no hemodynamically significant arterial inflow stenosis, an arterial diameter greater than 2 mm, a nondominant radial artery, a peripheral vein greater than 3 mm in diameter that spanned the length of the forearm or arm, and the absence of a central vein occlusion in the ipsilateral extremity. The autogenous access options included the radiocephalic, radiobasilic, brachiocephalic, and brachiobasilic configurations, in descending order of preference. Patients with suitable arterial inflow and venous outflow on the ipsilateral extremity, but without an acceptable peripheral vein for an autogenous access were considered candidates for prosthetic access with the brachial artery in either a brachial-antecubital (forearm loop) or brachial-axillary configuration. The subset of patients without autogenous access options and those with relative contraindications for a prosthetic access, usually because of a history of multiple prosthetic access failures from early thrombosis or infection, deemed at acceptable surgical risk were additionally considered for SFV ACCESS. These patients underwent further noninvasive imaging to confirm that the superficial femoropopliteal vein was a suitable conduit, to confirm that the lower extremity arterial circulation was sufficient to heal the vein harvest incision (popliteal pressure >50 mm Hg), and to determine that the saphenous vein was suitable to be used as a composite vein if the superficial femoropopliteal vein was not sufficient or as a conduit for a distal revascularization–interval ligation (DRIL) procedure if postoperative hand ischemia developed.[5] The lower extremity arterial studies included pressure measurements with determination of ankle-brachial indices and waveform analyses with continuous- wave Doppler scanning interfaced with an analog recording device (IMEX). The diameter and quality of the saphenous vein[6] and the superficial and femoral popliteal veins were examined with duplex ultrasound scanning. The deep veins were examined from the confluence of the tibial veins to the common femoral vein with an 8-MHz probe (Advanced Technology Laboratory) with the same technique used to look for deep venous thromboses. Superficial femoropopliteal vein segments were considered suitable for SFV ACCESS if their diameter was greater than 6 mm from the midpopliteal fossa to the termination at the confluence of the profunda femoral vein and there were no intraluminal defects. The arterial inflow and venous outflow on the upper extremity selected for the SFV ACCESS were further interrogated with standard contrast material–enhanced arteriography and venography to definitively confirm that there were not significant lesions, per the published algorithm.

Operative technique[3] (Fig 1). General endotracheal anesthesia was used for all the SFV ACCESS procedures. The patients were positioned with the upper extremity abducted to 90 degrees and positioned on a "hand table" extension. The operative field included the upper extremity and axilla, and both lower extremities. A 3-cm segment of the brachial artery was exposed immediately proximal to the antecubital fossa through a longitudinal incision. A similar length of axillary vein was exposed through a longitudinal incision starting in the proximal arm and extending into the axilla. It was usually necessary to remove all previous prosthetic accesses in the arm to facilitate exposure of the desired vessels and to create the tunnel for the vein graft. The superficial femoropopliteal vein was exposed through an incision that extended from the inferior aspect of the femoral triangle over the common femoral vein to the above-knee popliteal fossa on the lateral aspect of the sartorius muscle. The proximal and distal aspects of the thigh incision comprised those traditionally used for exposure of the common femoral and above-knee popliteal vessels, respectively. Alternatively, the vein can be exposed through an incision lateral to the sartorius muscle that extends from the proximal thigh to the knee. The superficial femoropopliteal vein was then dissected free caudally from its confluence with the profunda femoral vein to the midpopliteal fossa. Complete exposure of vein required incising the adductor canal and retracting the sartorius muscle. The multiple branches of the superficial femoropopliteal vein were ligated, with care to preserve the adjacent unnamed collateral arterial branches. The superficial femoropopliteal vein was excised flush with the profunda femoral vein to avoid any potential nidus for thrombus and immediately behind the patella in the midpopliteal fossa. A

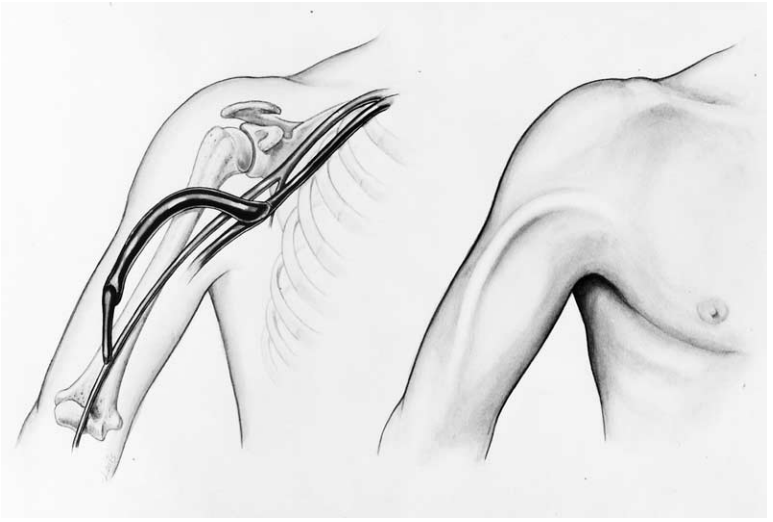

Fig 1. Original artist rendition of the autogenous brachial-axillary translocated superficial femoropopliteal vein access (SFV ACCESS) depicts a composite configuration with saphenous and superficial femoropopliteal vein, although this has rarely been necessary in our more recent experience. As noted in the text, the SFV ACCESS has the appearance of a mature brachiocephalic autogenous access. (From Huber TS, Ozaki CK, Flynn TC, Ross EA, Seeger JM. Use of superficial femoral vein for hemodialysis arteriovenous access. J Vasc Surg 2000;31:1038-41. Used with permission).

30-cm segment of vein can be harvested with the outlined technique, and this is usually sufficient to construct a brachial-axillary access that includes a generous lateral curve over the biceps muscle. The lumen of the vein was imaged with the angioscopy, and all defects were repaired. The tunnel in the arm was created with a 6-mm semicircular tunneller, and the vein was passed through the tunnel nondistended and in reverse orientation to maintain antegrade flow through the vein relative to its valves. The proximal and distal anastomoses were performed with 6-0 and 5-0 monofilament suture, with loupe magnification, after systemic heparinization. The access and the ipsilateral upper extremity pulses were interrogated by both physical examination and continuous wave Doppler scanning. Of note, the traditional thrill used to confirm the adequacy of the access was not always present in the SFV ACCESS, presumably because of the size of the vein, despite no technical defects and a patent ipsilateral central vein. Two No. 10 Jackson-Pratt drains were placed in the bed of the superficial femoropopliteal vein harvest, and brought out through separate stab wounds immediately above the knee. The vein harvest incision was closed in two layers, and the heparin effect was reversed with protamine if there was evidence of coagulopathic bleeding.

Symptomatic hand ischemia was treated with the DRIL procedure. Both the original arm incisions, that is, brachial and axillary, were extended to expose the brachial artery, and a tunnel was created between the intervening soft tissues. The proximal anastomosis for the DRIL procedure was sited on the brachial artery 10 cm proximal to the access anastomosis, and the distal anastomosis for the DRIL was sited immediately distal to the access anastomosis.

Postoperative care. Patients were admitted to the hospital after the procedure, and were closely monitored for the development of hand ischemia, wound infection or breakdown, and compartment syndrome. Patients with mild to moderate (grade 1-2[7]) hand ischemia were managed expectantly, and those with severe (grade 3) ischemia underwent the DRIL procedure. Patients were discharged when they were ambulatory, their incisional pain was under control with oral medications, and they were able to care for themselves. The Jackson-Pratt drains were removed when the output decreased to less than 50 mL per 8 hours, which was usually on the second postoperative day. Patients were followed up in the outpatient clinic biweekly until their wounds were healed and they could be successfully dialyzed through the SFV ACCESS. No set criteria were used to determine when the access was suitable for cannulation. Patients were not routinely seen in the outpatient clinic over the long term unless they had undergone a DRIL procedure. These patients were followed up at specific intervals with duplex ultrasound scanning of the bypass graft, similar to those patients undergoing infrainguinal arterial reconstruction. Patients in whom problems developed during dialysis from either reduced flow or elevated venous pressure underwent fistulography and remedial treatment with either balloon angioplasty or open surgical revision (vein patch angioplasty or interposition graft). Patients with thrombosed accesses underwent initial chemical lysis before endovascular or surgical revision.

Analyses and statistics. The primary, primary assisted, and secondary functional patency rates for the SFV ACCESS were reported with life table methods.[8] All continuous data were reported as the mean value ± SD. Patient

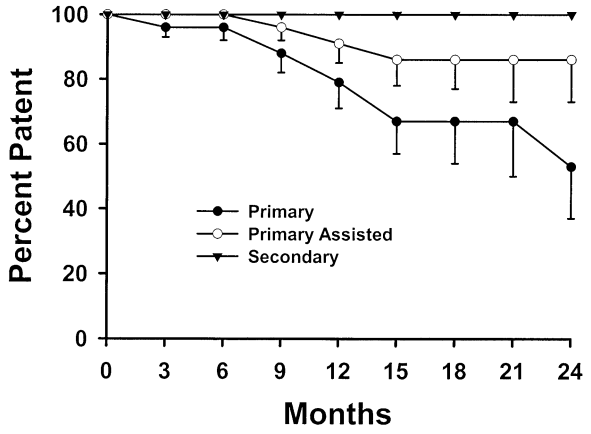

Fig 2. Primary, primary-assisted, and secondary life table curves and their corresponding negative standard error bars are shown for the SFV ACCESS. The standard error exceeds 10% at 15 and 18 months, respectively, for the primary and primary-assisted patency rates. Complete life table data are provided in Tables I through III, online only.

groups were compared with the Fisher exact test, and $P < .05$ was accepted as significant. The Health Center Institutional Review Board at the University of Florida approved the study (No. 332-2003).

RESULTS

A total of 30 patients underwent SFV ACCESS during the study period, among approximately 650 access-related open surgical procedures. The mean patient age was 54 ± 15 years, and most patients (67%) were women or African American (63%); a significant proportion had diabetes (50%) or were obese (21%; ≥125% ideal body weight). Diabetes (43%) and hypertension (23%) were the leading causes of ESRD. The patients had been receiving dialysis for 4 ± 5 years (range, 0-24 years), and had undergone on average 3 ± 3 (range, 0-17) previous permanent hemodialysis access procedures. The overwhelming majority of the patients were actively dialyzed through tunneled catheters (tunneled hemodialysis catheter, 90%; peritoneal dialysis catheter, 3%; prosthetic hemodialysis access, 7%).

The 30-day-in-hospital mortality rate was 3%, and the 60-day mortality rate was 7%. Of note, the mortality for all open surgical access-related procedures at our institution over the past 13 months was 3.6%. One patient in the current study died before discharge, of respiratory arrest, and a second patient was readmitted in the early postoperative period with wound problems and had a fatal arrhythmia. Fifty-seven percent of the patients experienced some type of perioperative complication, and 38% required some type of remedial surgical procedure as a result of the complication. Significant hand ischemia developed in 43% of the patients (severity score 1 [mild], 10%; 2 [moderate], 7%; 3 [severe], 27%), and required a DRIL procedure in 27%, or all those with a severity score of 3. There were no significant differences in the incidence of hand ischemia between patients with or without diabetes (47% vs 40%), male or female patients (20% vs 55%; $P = .12$), and patients older or younger than 65 years (29% vs 48%). Of note, three fourths of the DRIL procedures were performed within the first postoperative month. Thigh wound complications or hematomas developed in 23% of the patients, and arm wound complications or hematomas developed in 17%. There was a significant difference in the incidence of thigh complications or hematomas between obese and nonobese patients (57% vs 13%; $P = .03$), but not for arm complications or hematomas (42% vs 9%; $P = .07$). Calf compartment syndrome developed in two patients (7%), necessitating a fasciotomy ipsilateral to the superficial femoropopliteal vein harvest. Of note, the saphenous vein was harvested for a DRIL procedure ipsilateral to the superficial femoropopliteal vein harvest in one of these patients. The mean hospital length of stay after the SFV ACCESS was 7 ± 7 days, and 7% of the patients were subsequently readmitted because of some type of perioperative complication, for a total postoperative length of stay of 9 ± 12 days. The SFV ACCESS was initially cannulated for dialysis at 7 ± 1 weeks postoperatively.

The primary, primary assisted, and secondary patency rates for the SFV ACCESS were 96% ± 4%, 100% ± 0%, and 100% ± 0%, respectively, at 6 months; 79% ± 8%, 91% ± 6%, and 100% ± 0%, respectively, at 12 months; and 67% ± 13%, 86% ± 9%, and 100% ± 0%, respectively, at 18 months (Fig 2; Tables I-III, online only). The three accesses that thrombosed were all successfully treated with chemical lysis. No identifiable cause for the thrombosis was found in one patient, whereas critical stenoses were found in the superficial femoropopliteal vein segment in the other two patients and required open surgical revision (interposition graft, vein patch angioplasty). The procedures to maintain patency among the "failing" accesses with critical stenoses included balloon angioplasty (n = 2) and interposition grafting (n = 3) in the superficial femoropopliteal vein segment or central veins. Both patients (7%) with compartment syndrome experienced moderate to severe leg edema (severity score, 2^7), and 50% of the patients complained of mild pain, numbness, or edema (severity score, 1) in the extremity ipsilateral to the deep vein harvest. One patient (3%) with moderate peripheral vascular occlusive disease required an above-knee amputation ipsilateral to the deep vein harvest, and a second patient (3%) with a known ipsilateral central vein occlusion had moderate arm edema (severity score, 1). In one patient with a "failing" DRIL procedure who refused follow-up digital gangrene developed, which required a finger amputation.

DISCUSSION

The intermediate-term functional patency rate for the SFV ACCESS is excellent, although the procedure is associated with a significant cost in terms of perioperative morbidity and mortality. The patency rate is comparable to that reported for other autogenous accesses, and significantly better than that usually reported for prosthetic conduits. Of note, we recently reported a systematic review of

the literature examining the patency rates of upper extremity accesses in adults, and found that the 12-month primary patency rate was approximately 60% for autogenous configurations and 40% for polytetrafluoroethylene (PTFE), with corresponding secondary patency rates of 80% and 60%, respectively.[9] The results of our current series are even more impressive, given that the patient population had complex access problems with limited options and multiple previous procedures. The studies that composed our systematic review did not consistently report perioperative complications in a standard fashion; however, there were few perioperative deaths (median, 0%; range, 0%-1%), and both the hand ischemia (median, 2%; range, 0%-14%) and access-related infectious complications (median, 7%; range, 0%-30%), which comprised two of the largest individual complications, were also low. This is in stark contrast to our current report, with its 3% in-hospital 30-day mortality rate and 57% overall complication rate, which includes a 27% rate of DRIL procedures for hand ischemia.

We have maintained a significant amount of enthusiasm for the SFV ACCESS despite the associated complications, and contend that the characteristics of the vein and the excellent patency rates justify the procedure. The mean diameter of the superficial femoropopliteal vein in adults is 7 mm at its mid-portion,[10] and the wall is thick relative to either the basilic or cephalic vein. Indeed, the SFV ACCESS has the appearance and handling characteristics of a mature, arterialized brachiocephalic autogenous access. Most of the complications associated with the SFV ACCESS, with the obvious exception of perioperative death, are remediable and associated with reasonable long-term outcomes. Admitted, the complications prolong hospital stay and require additional health care resources, and costs, in terms of subacute care facilities or visiting nurses. In addition, the long-term patency rate for the DRIL procedure remains undefined, and, despite our enthusiasm, the published experience is less than 200 procedures.[5,11-15] It is also disturbing that the perfusion to the affected hand after a DRIL procedure is completely dependent on the brachial artery bypass. Last, the mortality in the current study, although significant, was comparable to that for our access practice as a whole, and attests to the fact that patients with ESRD are at modest operative risk despite what seems to be a fairly minimal procedure. Indeed, the annual unadjusted death rate for all patients with ESRD across the United States is 177.6 per 1000 patient-years at risk.[16]

We concede that the role of the SFV ACCESS in patients with complex access problems is debatable in light of the associated morbidity and mortality, given that there are other access alternatives. Essentially all of the patients in our series could have received a brachial-axillary prosthetic access (or an additional brachial-axillary prosthetic access), a tunneled catheter, or a femorofemoral inguinal access with either autogenous or prosthetic conduit. Furthermore, we have reported that all that is necessary to construct a permanent hemodialysis access is an arterial inflow site, a venous outflow site, and some type of conduit,[12] whereas the literature is replete with a variety of "heroic" configurations.[17] The study patients were considered for SFV ACCESS only if we thought they would not derive significant additional benefit from a brachial artery–based prosthetic access, although this is subjective. Furthermore, the use of temporary catheters increases the mortality for patients with ESRD relative to autogenous or prosthetic accesses,[18-20] while the infectious complications of thigh prosthetic accesses are significant and may be prohibitive.[21-24] Cull et al[25] recently reported that the incidence of infectious complications after 125 prosthetic thigh accesses was 41% and the 2-year primary patency rates were only 19%, and concluded that tunneled catheters are a superior option. Of note, Jackson[25] and Gradman et al[26] reported transposing the superficial femoral vein in the thigh to create an autogenous access. The patency rates reported by Gradman et al[26] were excellent (12 months: primary, 73%; secondary, 86%), although the complication rates (major wound, 28%; remedial procedure to treat ischemia, 32%; major amputation, 4%) were significant and comparable to those in our series. In addition, the long-term outcome after many of the heroic options remains to be defined, and may represent little more than short-term solutions.

The algorithm defining our hierarchy of access configurations outlined in the Methods section reflects our current practice, although the results of the study have forced us to reexamine the indications for the SFV ACCESS. The net effect is that we have become somewhat more conservative about recommending the procedure. Our univariate analyses did not enable us to identify the subsets of patients at risk for hand or wound complications, with the exception of the increased incidence of thigh complications in obese patients. We presently reserve the procedure for patients who are compliant, at good operative risk, with a reasonable life expectancy, and with a suitable segment of saphenous vein that could be used for a DRIL procedure. Patients must be compliant, because those who require a DRIL procedure need long-term follow-up of the graft. It is likely that we could have prevented the digital amputation in the patient with the "failing" DRIL procedure had we known that she was having problems. There are no specific criteria to define "good risk" other than plain surgical judgment. The patient's cardiac and pulmonary systems should be sufficient to tolerate a major operation. We have weighed the known preoperative risk factors for developing hand ischemia after a brachial artery–based access into our decision process, including female gender, peripheral vascular occlusive disease, age, and diabetes. The preoperative noninvasive and invasive arterial imaging studies have helped identify any significant arterial occlusive disease. However, none of the patients in whom hand ischemia developed had any evidence of discrete, hemodynamically significant arterial inflow lesions, and few had any evidence of forearm disease. We have hypothesized that the hand ischemia results from the fact that the compensatory changes in the arterial inflow are insufficient to overcome the decrease in resistance from the fistula, and that the resultant decrease in arterial pressure is further exacerbated

by any forearm occlusive disease. We have not attempted to quantify the flow through the SFV ACCESS, but would hypothesize that it is significant and likely greater than with PTFE or other non-autogenous biologic conduits. Of note, Matsuura et al[27] reported a 3% incidence of hand ischemia with PTFE brachial-axillary accesses and a 2% incidence for cryopreserved femoral vein grafts in the same location. We have also factored the patient's weight and body habitus into the decision algorithm, because of the significant incidence of wound complications. Harvesting the superficial femoropopliteal vein is substantially more challenging in obese patients, and is associated with a greater incidence of thigh wound complications. Indeed, most of the prolonged hospital stays after the SFV ACCESS were due to thigh wound complications. It has been our impression that placing the Jackson-Pratt drains helps eliminate the anatomic dead space after the harvest and promotes apposition of the tissues. Last, the criterion that patients have a reasonable life expectancy simply represents an attempt to balance the cost of the procedure in terms of the perioperative morbidity and mortality and the benefit in terms of a successful access.

There are several points regarding the study and the procedure that merit further comment. First, the long-term follow-up is somewhat limited. The standard error for the life table data exceeded 10% (a reliability threshold for the life table method) after 15 and 18 months for the primary and primary-assisted patency rates, respectively. It is impossible to determine how the SFV ACCESS will hold up beyond the time frame of the study. However, the patency for all prosthetic and autogenous access procedures is somewhat limited, and usually quoted in the 6-month to 18-month range. Second, there are several available treatment options for patients with hand ischemia other than the DRIL procedure, including simple ligation and banding. We have felt compelled to salvage the SFV ACCESS in patients in whom hand ischemia developed, given the magnitude of the procedure, although our first priority is clearly to maintain a normal, functional hand. Our enthusiasm for any type of banding procedure is somewhat limited, although we have had some anecdotal success in other settings in patients with persistent hand ischemia despite a successful DRIL procedure.[28] Third, we have not developed a formal surveillance plan, nor have we routinely seen patients in the clinic long-term after the SFV ACCESS, with the exception of those who have undergone a DRIL procedure. However, we have established a nice relationship and open lines of communications with the surrounding dialysis centers, and maintain a low threshold for obtaining a fistulogram if there is any concern about the integrity of the SFV ACCESS. Fourth, we have become reluctant to harvest the saphenous vein ipsilateral to the superficial femoropopliteal vein harvest, and vice versa in patients in whom the the saphenous vein has been harvested, because of the potential for development of significant venous hypertension or a compartment syndrome, despite the fact that the profunda femoris vein is reportedly the main collateral vessel for the superficial femoropopliteal vein.[29] Last, we have considered an ipsilateral central vein occlusion only a relative contraindication to SFV ACCESS. We have been impressed with the number of patients in our access practice (not just patients with an SFV ACCESS) with a patent, functional access and an ipsilateral central vein occlusion who do not have significant arm edema. Furthermore, we have been impressed that, when we have placed a new access in patients with an ipsilateral central vein occlusion, few have had significant, persistent arm edema that requires dissembling the access. However, we would proceed with an SFV ACCESS in the presence of a known central vein occlusion only after a prosthetic brachial-axillary access failed, presuming that the arm edema was manageable.

In conclusion, the functional patency rates after SFV ACCESS are excellent, although the magnitude of the procedure and the complication rates are significant. SFV ACCESS should be considered only in patients with limited access options.

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Submitted Jan 19, 2004; accepted Apr 6, 2004.
Available online Jun 18, 2004.

Additional material for this article may be found online at www.mosby.com/jvs.

DISCUSSION

Dr David L. Cull (Greenville, SC). Traditionally, the patency rate has been considered the most important outcome measure for arteriovenous access procedures. Using this standard, the autogenous brachial-axillary arteriovenous (AV) access with SFV is an exceptional procedure, since the patency results obtained by Dr Huber were superb. We must, however, carefully consider the cost and morbidity of this procedure in determining its role in relation to other tertiary AV access procedures such as the prosthetic thigh or chest wall arteriovenous access.

To achieve these results Dr Huber's group performed an extensive preoperative work-up. Despite the obvious care undertaken to ensure good outcomes for these patients, the complication rate was significant. Fifty-seven percent of patients suffered a perioperative complication, and 38% required a remedial operation. Most concerning was a 43% incidence of arterial steal, which was significant enough to require a DRIL procedure in 27% of patients.

I have the following questions for the authors. To perform this procedure you must use vein from 2 potential sites for AV access placement, the leg and the arm. Are you concerned that harvest of the SFV will preclude future AV access placement in that thigh? If so, would these patients have been better off receiving a prosthetic upper arm access, then a prosthetic thigh access when the arm access failed? Three years ago, Gradman reported a series of patients who underwent superficial femoral vein transposition in the thigh for AV access. He reported secondary patency results similar to yours. Given his results and the problems with steal in the upper extremity, why not transpose the superficial femoral vein in the thigh rather than moving it to the arm? Finally, with your extensive experience with this procedure, what lessons can you give us regarding minimizing the incidence of these complications. For example, have you changed your patient selection criteria? Have you changed your technique, such as limiting the length of the arterial anastomosis? To do so might decrease your patency rate; however, it might also reduce the incidence of arterial steal.

Dr Thomas S. Huber. I would say that our group has maintained a fair amount of enthusiasm for the procedure, and I would contend that this is based on the excellent patency rates in a very difficult subset of patients. These are truly patients without any other access options. The deep vein behaves just like a mature, arterialized brachiocephalic fistula. It is about 7 to 10 mm in diameter and it's a very thick-walled, sturdy vein. We have conformed pretty strictly to our previously published algorithm. All the patients presenting for access are evaluated for some autogenous access and the majority of the patients in our practice have an autogenous option. In those who are not candidates, we use prosthestic accesses much like everyone else. Most of the patients in this setting cannot have a forearm access because the bridge has usually been burned. The patients who received an SFV access in our algorithm were those who we thought could not have another piece of plastic in their arm. That's the subset of patients that we are talking about. Yes, we have burned a few bridges conceivably, but these are patients that we deemed very poor candidates for additional prosthetic accesses in their arms. The other options are certainly tunneled catheters forever or thigh access. Our enthusiasm for thigh access has been somewhat limited. The experience in the literature is variable, with infectious complication rates ranging up to 40% or 50%.

So what have we learned from this experience? Part of the motivation for the study was to go back and look at our experience for our own benefit to find out how well we are doing. On the basis of what we have learned, we have become a little more conservative. I think the SFV access is an appropriate access for compliant, good risk patients with reasonable life expectancy who have a suitable piece of saphenous vein in case a DRIL procedure is necessary. The patients must be compliant because they have to come back to clinic. We could have prevented the 1 woman from losing her finger if she had come back to clinic. The patients must be a good surgical risk because the magnitude of the procedure is comparable to femoropopliteal bypass. We consider the preoperative risk factors for hand ischemia, including arterial occlusive disease or diabetes, gender, and age, even though they didn't shake out as predictors in our own experience. We have also been a little more conservative about recommending it in obese patients because of the wound complication rate. I don't think that minimizing the arterial anastomosis makes any real impact. There is a very nice chapter in one of standard access textbooks outlining the physics involved with the access flow, and unless you narrow your anastomosis more than 75% the arterial diameter you don't really limit the flow through that anastomosis, so that hasn't been particularly beneficial. And I must say, despite our incidence of

hand ischemia, all these people had preoperative arteriograms. They didn't have any obvious arterial inflow problems and very few of them had any forearm vascular disease.

The other questions concerned whether we precluded people from getting thigh accesses. I don't think so. We harvest the SFV/popliteal vein from the confluence of the deep vein to immediately behind the knee, but patients could certainly have thigh accesses based off the common femoral vein and the common femoral artery. Admittedly, it might bit a little more difficult to make the tunnel because of the incision.

The other question that you asked was our experience with thigh deep vein accesses. Early in our experience, we had some really bad outcomes with this configuration due to wound breakdown. The grafts became exposed and the patients developed ischemic complications of the leg. We have really backed away from that configuration. However, it may be worthwhile revisiting it in the future.

Dr Kenneth McIntyre (Las Vegas, NV). I am interested in how long it takes you to do this procedure? Wayne Gradman takes a piece of PTFE on the arterial inflow side and buries it deep to the muscle. He uses the SFV transposed into the superficial position so that the part that is stuck by the dialysis technicians is in the superficial position. I think that this composite graft offers some real possibility.

Dr Huber. As I mentioned, perhaps it's time to go back to those options. As far as the time, it takes somewhere between 2 to 3 hours to perform the operation. The brachial artery and axillary vein dissection are a piece of cake and take about 30 or 40 minutes. Harvesting the deep vein takes somewhere between an hour to an hour and a half. Furthermore, it is helpful to have an assistant to help tie the multiple branches.

Dr McIntyre. But you were doing it just with 1 team?

Dr Huber. We use a single team. The arm exposure is performed first and then the deep vein harvest.

Dr W. Charles Sternbergh (New Orleans, La). I enjoyed your paper. I have a comment about your preoperative evaluation. Clearly, your use of arteriography and venography is substantial and much more than the average dialysis-access patient receives. Perhaps your great patency rates are due in part because of this exhaustive preoperative evaluation. You may have excluded occult vascular problems that we all occasionally miss. Of people who were potential candidates for this, whom you subjected to arteriography and venography, what percentage was found to be unsuitable because of occult vascular problems?

Dr Huber. I'm not certain I can answer that specifically for this subset of patients. As I said earlier, a couple of years ago we presented our access algorithm, which is basically the same one we used for this study. We found that there was some type of abnormality on the arteriograms and venograms in 40% of the people and that 20% of the time these findings had an impact on what we did as far as our operative plan. The majority of the patients had more forearm vascular disease than we had appreciated and you might predict from our diabetic population. We have become more reliant on the noninvasive imaging and obtain fewer arteriograms with the exception of people that have known vascular disease or diabetes. As far as venography, we likewise have backed away from it and have been impressed with the fact that central vein occlusion or central vein stenosis is only a relative contraindication to ipsilateral access.