Venous reconstructions using the superficial femoral–popliteal vein

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Purpose: **To demonstrate the feasibility of venous reconstructions with the superficial femoral–popliteal vein (SFPV).**
Methods: **Seven patients who underwent a variety of major venous reconstructions using SFPV were reviewed in a retrospective, observational study.**
Results: **Three central venous reconstructions (thoracic and abdominal) and four peripheral major venous reconstructions were performed with SFPV autografts. In all patients, the SFPV grafts provided an excellent size match and were of adequate length without the need for enlargement by paneling or spiraling techniques. Postoperative anticoagulation medication was not used. There were no early graft failures, and patency was documented by duplex ultrasound, venogram, or both in all patients at a mean of 20 months follow-up. Venous thromboembolism has not occurred, and lower extremity venous morbidity has been minimal.**
Conclusions: **The SFPV graft demonstrates versatility and durability in selected patients who require large-caliber conduits for venous reconstruction. Because of its size and availability, the SFPV is an excellent conduit for major venous reconstruction. (J Vasc Surg 1997;26:829-37.)**

Major venous reconstructions are compromised by the lack of nonthrombogenic, large-caliber conduits that will remain patent in the low-pressure, low-velocity venous system.[1,2] The wide availability of polytetrafluoroethylene (ePTFE) prostheses in large diameters has led many investigators to recommend these as conduits for venous bypass grafting.[3-7] Patency rates of prosthetic venous bypass grafts range from 50% to 100% at 5.5- to 60-month follow-up.[5-11] However, acceptable graft longevity requires the use of external supporting rings, proximal arteriovenous fistulae, chronic anticoagulation, antiplatelet therapy, or a combination of these. The autologous spiral vein graft fashioned from greater saphenous vein has demonstrated excellent patency, particularly when used to reconstruct nonmalignant occlusive disease of the superior vena cava (SVC) and branches.[10-13] Unfortunately, the technique can be time-consuming and technically demanding. In addition, the lack of a suitable length and quality of greater saphenous vein may confound attempts at creating a spiral conduit.

The superficial femoral–popliteal vein (SFPV) has been used as a conduit for in situ aortoiliofemoral arterial reconstruction after aortic prosthetic graft infection with excellent long-term results.[14-16] Patency in these arterial reconstructions has been unencumbered by late graft dilation or stenosis. The ready availability of long segments of this large-diameter vein makes it an ideal autologous conduit for these complex problems. We have also used the SFPV for major venous reconstructions. For the same reasons of availability, durability, size, and length, we believe the SFPV is an ideal conduit for venous reconstruction. The purpose of this study was to document the feasibility and durability of the SFPV graft in a heterogenous group of major venous reconstructions.

METHODS

All major venous reconstructions that required bypass grafting during the past 5 years were performed using SFPV. Inpatient records, vascular laboratory studies, and outpatient clinic charts were reviewed. Follow-up was established through medical records, telephone interviews, and clinic visits. Graft patency was established using noninvasive test-

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Presented at the Ninth Annual Meeting of the American Venous Forum, San Antonio, Tex., Feb. 20–24, 1997.
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0741-5214/97/$5.00 + 0 **24/6/84010**

Table I. Venous reconstructions

Patient no.	*Age (yr)/sex*	*Presentation*	*Cause*	*Reconstruction*	*Graft diameter (mm)*	*Patency/study*	*Clinical result*	*Donor limb venous morbidity*
1	46/M	SVC syndrome	Epithelial hemangioendothelioma	Bilateral IV-RAA	12	34 mo/duplex	Asymptomatic	None
2	62/F	SVC syndrome	Thymoma	Left IV-RAA	10	3 mo/duplex	Improved	None
3	37/M	Acute renal failure	Iatrogenic renal vein injury	Left renal vein-IVC	15	54 mo/duplex	Asymptomatic	None
4	64/M	Recurrent squamous cell carcinoma	Bilateral radical neck dissections	Left IJV interposition	10	14 days/duplex	Improved	None
5	26/M	Left SCV thrombosis	Percutaneous dialysis catheter	Left axillary-IJV	10	13 mo/duplex	Asymptomatic	None
6	6/F	Intracranial venous hypertension	Dural arteriovenous malformation	Sagittal/transverse sinus-right IJV	5	21 days/ venogram	Improved	None
7	18/M	Right CFV injury	Gunshot wound	Right SFV-CFV	12	37 mo/duplex	Asymptomatic	None

IV, Innominate veins; *RAA,* right atrial appendage; *IVC,* inferior vena cava; *IJV,* internal jugular vein; *SCV,* subclavian vein; *SFV,* superficial femoral vein; *CFV,* common femoral vein.

ing, invasive contrast studies, or both. Functional results were documented on a case-by-case basis.

The technique of harvesting the SFPV has been previously described,[14] but will be briefly reviewed here. Preoperative lower extremity venous duplex examination is used to confirm the size and patency of the SFPV. Additional information, such as scarring and recanalization after prior thrombosis or the presence of duplications or congenital hypoplasia with dominant profunda femoral venous drainage, can be invaluable in planning an appropriate operation. A longitudinal incision made over the lateral border of the sartorius muscle allows wide exposure of the SFPV. The adductor canal is exposed along its length by medial retraction of the sartorius muscle. The SFPV is found posterolateral to the superficial femoral artery and is isolated with a vessel loop. Meticulous dissection allows individual ligation of the numerous branches. Proximal dissection is carried to the junction of the SFPV with the profunda femoral vein. Distal dissection is varied according to the length of conduit required for the reconstruction. If necessary, the insertion of the adductor magnus can be divided, the adductor hiatus opened, and the dissection carried onto the popliteal vein. Care must be taken to preserve the saphenous nerve, which runs parallel to the SFPV in Hunter's canal. Injury can result in a temporary, but annoying, neuralgia. When an appropriate length of conduit is established, the proximal SFPV is divided flush with the profunda femoral vein and oversewn with polypropylene monofilament. Distal ligation is performed with permanent suture ligature. After hemostasis is achieved, the vein harvest site is closed without drainage in multiple layers using absorbable suture. In the postoperative period, aggressive prophylaxis against deep venous thrombosis is initiated using subcutaneous heparin and intermittent pneumatic compression.

RESULTS

Patients and results are summarized in Table I.

Central (abdominal and thoracic) venous reconstructions

Case 1. A 46-year-old man had a mediastinal mass noted on routine chest roentgenogram. A computed tomogram (CT) of the chest confirmed the presence of a mass in the right pretracheal space behind the right innominate vein, and biopsy demonstrated a malignant epithelial hemangioendothelioma. The mass was resected en bloc with the distal right and left innominate veins and SVC. Reconstruction of the great veins was achieved using an SFPV graft placed between the right and left innominate veins and the right atrium (Fig. 1). Central venous pressures of 25 to 30 mm Hg decreased to normal after the bypass procedure. Color flow duplex ultrasound examination confirmed a patent bypass graft 34 months after implantation without the use of chronic anticoagulation medication. He remains free of tumor recurrence and has not had lower extremity swelling or venous morbidity 3 years after operation.

Case 2. A 62-year-old woman with a previously irradiated, poorly differentiated thymoma was admitted with progressive postural dyspnea, cough, and facial swelling. The chest CT is pictured in Fig. 2.

The preoperative venogram confirmed SVC occlusion (Fig. 3). On exploration through a median sternotomy, the tumor and associated severe fibrotic reaction were found to be encasing a thrombosed SVC and right innominate vein. After tumor resection, a 14 cm length of SFPV was harvested, and a left innominate–to–right atrial bypass graft was placed. The vein graft, when gently distended, measured 10 mm in diameter, providing an adequate size match with the innominate vein remnant. The patient's postoperative course was complicated by respiratory failure and gastrointestinal bleeding. A duplex examination 3 months after the operation demonstrated a patent mediastinal bypass graft, and the patient has had no lower extremity venous morbidity.

Case 3. A 37-year-old man had acute renal failure after a right nephrectomy for complications of polycystic kidney disease. This operation was complicated by the unrecognized ligation and division of the left renal vein. Exploration confirmed a 2- to 3-cm gap between the distal end of the left renal vein and the inferior vena cava. After thrombectomy, primary reanastomosis was not feasible because of retroperitoneal edema and renal swelling. A left renal vein–to–inferior vena cava bypass graft using SFPV was placed. The 15 mm diameter SFPV provided an excellent size match with the left renal vein. Return of renal function was immediate, and hemodialysis was discontinued. This case has been previously reported,[17] and longer follow-up is now available. The patient continues to do well with normal renal function; duplex examination demonstrated patency 54 months after reconstruction without the use of chronic anticoagulant or antiplatelet therapy. He had transient donor limb swelling treated with 30 to 40 mm Hg compression for approximately 6 months.

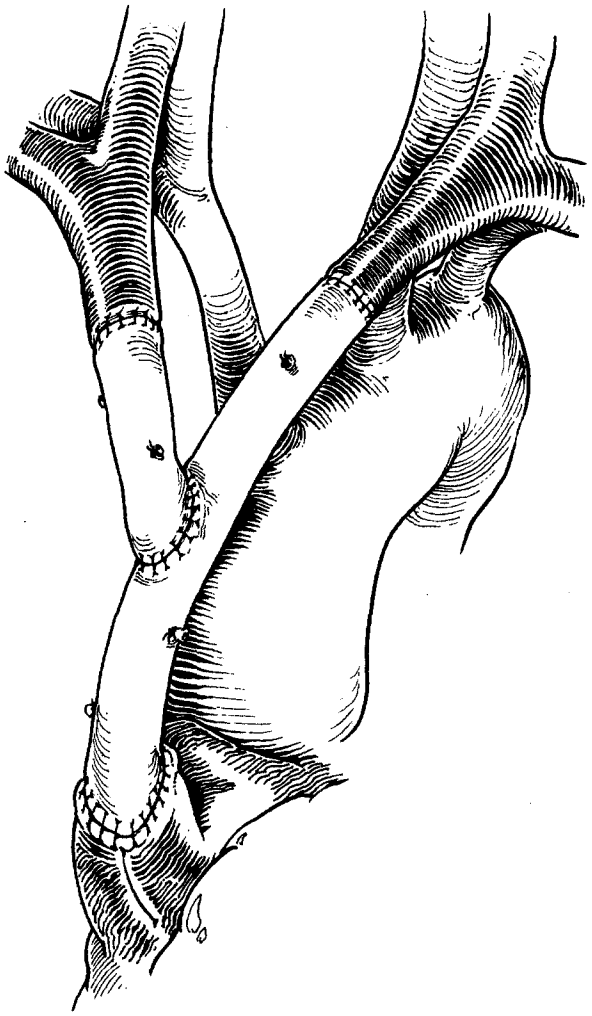

Fig. 1. Bilateral innominate vein–to–right atrial appendage bypass graft using SFPV.

Peripheral venous reconstructions

Case 4. A 64-year-old man had recurrent squamous cell carcinoma of the left neck. Ten months earlier, he had undergone a partial glossectomy and left modified radical neck dissection with adjuvant radiotherapy for squamous cell carcinoma of the tongue. Simultaneous bilateral radical neck dissections were performed, and the left internal jugular vein was reconstructed using a 10 mm diameter SFPV harvested from the left thigh. Early patency was confirmed at 14 days by duplex ultrasonography, and the patient died 2 months after resection from metastatic disease.

Case 5. A 26-year-old man with end-stage renal disease had been plagued by multiple dialysis arteriovenous graft failures. Upper extremity and lower extremity dialysis grafts had failed after repeated thrombectomies and revisions. In addition, multiple temporary subclavian dialysis catheters had been placed. The patient returned 17 months after placement of a left upper arm brachial artery–to–axillary vein ePTFE loop with severe upper extremity swelling, cyanosis, and pain while on hemodialysis. A venogram confirmed a thrombosed left subclavian vein. Using both supraclavicular and infraclavicular incisions, a left axillary vein–to–left internal jugular vein bypass graft was constructed using the right SFPV (Fig. 4). Symptomatic relief was immediate, and venous pressures during dialysis returned to normal. The ePTFE loop thrombosed 11 months later, and cadaveric renal transplant was performed. This was complicated by hemorrhagic pancreatitis, sepsis,

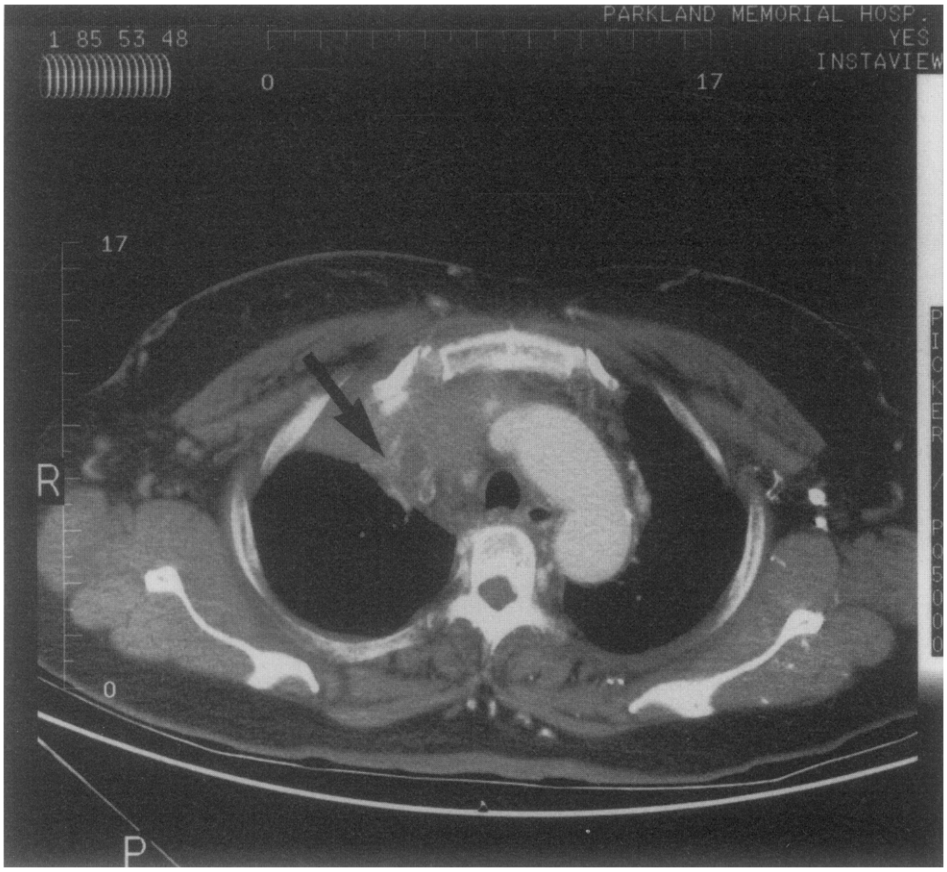

Fig. 2. Chest CT scan demonstrates tumor mass encasing a thrombosed SVC *(arrow)*.

and multiple organ failure, and the patient died 2 months after transplantation. Interestingly, a venous duplex examination performed 1 month before death revealed a widely patent axillo–internal jugular vein bypass graft despite the thrombosed arteriovenous loop.

Case 6. A 6-year-old girl had a dural arteriovenous malformation (AVM) draining into the superior sagittal sinus and a thrombosed cavernous sinus. Despite initial control with endovascular embolotherapy, progressive severe headaches, papilledema, and refractory seizures ensued over a 12-month period. A repeat arteriogram revealed revascularization of the dural AVM. Status epilepticus developed, and the patient was responding only to pain. Emergent ventriculostomy confirmed markedly elevated intracranial pressures. Further attempts with embolotherapy, ventriculoperitoneal shunting, and craniectomy with temporal lobe resection were unsuccessful in relieving cerebral edema. In an attempt to control her cerebral venous hypertension, a superior sagittal sinus–to–right internal jugular bypass procedure with a SFPV graft was performed. On preoperative duplex scan, her greater saphenous veins were small (2 mm), but both SFPVs were of adequate diameter (5 to 6 mm) for bypass grafting. Cerebral swelling decreased, and a postoperative angiogram performed 3 weeks after bypass grafting demonstrated a widely patent venous bypass graft (Fig. 5). One month after the bypass procedure, the patient died during attempted repair of an associated dural cerebrospinal fluid leak.

Case 7. An 18-year-old man had a gunshot wound to the right groin and profuse bleeding. Emergent exploration demonstrated a complex common femoral vein injury involving the confluence of the profunda and superficial femoral veins. The contralateral SFPV was used to reconstruct the femoral vein bifurcation, with an interposition graft between the right SFPV and the common femoral vein (Fig. 6). The right profunda femoral vein was ligated. A postoperative duplex examination confirmed a patent reconstruction and an excellent size match between the graft and the common femoral vein. Oral anticoagulation medication was not used. A late duplex follow-up study performed at 37 months re-

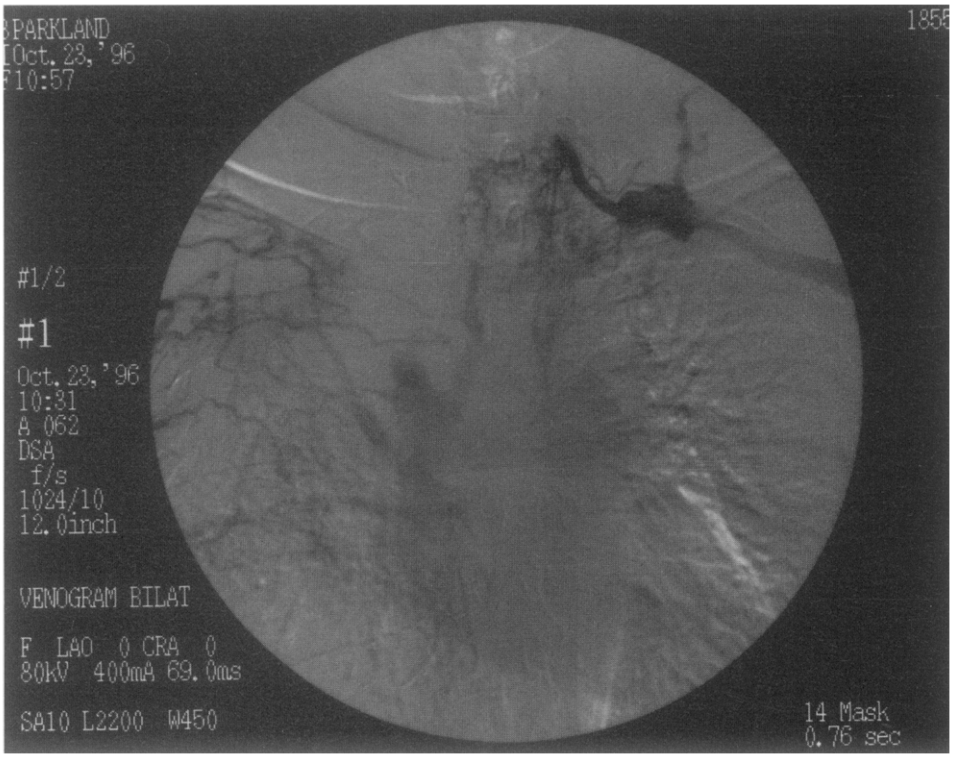

Fig. 3. Venogram demonstrates occlusion of SVC in a patient with a poorly differentiated thymoma.

Fig. 4. Left axillary vein–to–internal jugular venous bypass graft.

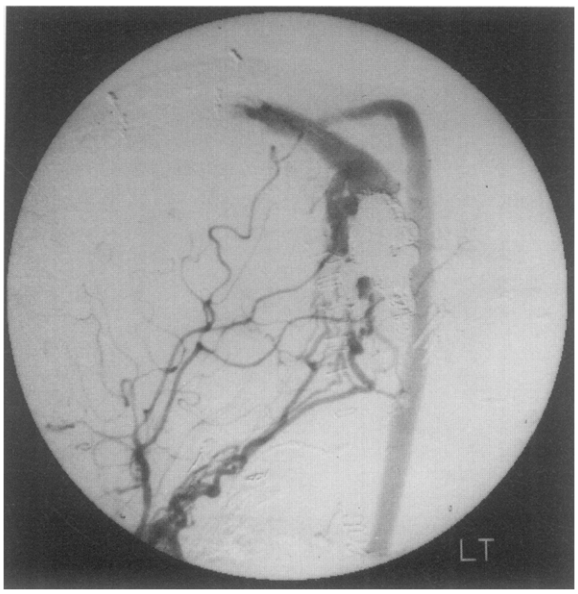

Fig. 5. Venous phase of this cerebral arteriogram demonstrates a widely patent superior sagittal sinus–to–right internal jugular vein bypass graft using SFPV 3 weeks after implantation.

vealed a widely patent graft, and no long-term swelling, skin changes, or venous symptoms have developed.

DISCUSSION

Major venous reconstructions with the SFPV have been previously reported. In 1951, Klassen and colleagues[18] first described its use to bypass SVC obstruction in a 26-year-old patient with fibrosing mediastinitis from anthracosis. Scattered reports[18-22] over the past five decades reflect a sporadic experience with SFPV bypass grafting for relief of SVC syndrome (Table II). Versatile applications ranged from simple bypass grafting and proximal azygos-SVC shunt to the use of a pantaloon bifurcated graft from both innominate veins to the atrial appendage. Although follow-up was variable (8 days to 8.5 years), late venograms were available in the majority of patients; all venograms demonstrated patent, functioning grafts 3 to 42 months after implantation. Despite the success and longevity of these bypass grafts in treating SVC syndrome, the use of SFPV as a venous bypass conduit has never become popular. Perhaps this reluctance is based on fears of excessive venous morbidity in the donor limb and difficulty in harvesting the autograft. Recent experience with arterial reconstructions using SFPV has documented a lack of serious venous morbidity associated with removal of the deep vein.[14-16] Therefore, wider application of these grafts can be anticipated.

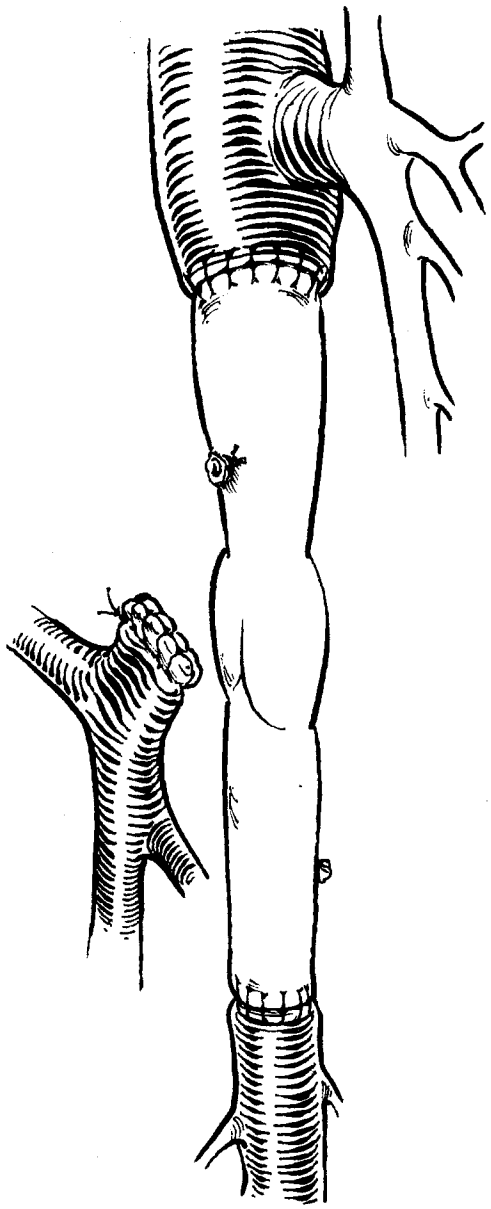

Fig. 6. Venous reconstruction of left common femoral vein using contralateral SFPV. The graft was interposed between the superficial femoral vein and the common femoral vein. The profunda femoral vein was ligated.

The two patients we treated for SVC syndrome with SFPV bypass procedures remain without symptoms, with graft patency confirmed by color flow duplex ultrasound at 3 and 34 months. Patency was not facilitated by the use of oral anticoagulant medications or temporary arteriovenous fistulae. These results compare favorably with those obtained with reconstructions using spiral saphenous vein grafts

Table II. Published cases of SVC reconstruction with SFPV

Author/year	*No. of patients*	*Cause*	*Reconstruction*	*Objective patency/study*	*Clinical outcome/follow-up*
Klassen et al./1951[18]	1	Anthracosis	Azygos-SVC	5 mo/venogram	Asympatomatic/5 mo
Scannel et al/1954[19]	2	Radiation fibrosis	Right IJV-SVC	8 days/autopsy	Died of mediastinitis
		Organized traumatic hematoma	Right IJV-RAA	3 mo/venogram	Asympatomatic/12 mo
Hanlon et al./1965[20]	2	Inflammatory mass	Right IV/left IV-SVC	42 mo/venogram	Asymptomatic/8.5 yr
		Mediastinal sarcoma	Left IV-RAA	None	Asymptomatic/5 yr
Gladstone et al./1985[21]	2	Idiopathic fibrosing mediastinitis	Right IJV-SVC	12 mo/venogram	Asymptomatic/12 mo
		Poorly differentiated carcinoma	Left IV-SVC	None	Asymptomatic/9 mo
Marshall et al./1988[22]	1	Failed spiral vein graft	Left IV-RAA	24 mo/venogram	Asymptomatic/24 mo

IJV, Internal jugular vein; *RAA,* right atrial appendage; *IV,* innominate vein.

(SSVGs) and ePTFE for relief of SVC obstruction.[4-8,10-13] In addition, the reports of Doty and colleagues[12,13] relate SSVG diameters that range from 9 to 15 mm constructed over 28F to 40F chest tube stents. We reported that the average diameter of 41 SFPVs used for in situ aortic reconstruction was 10.2 ± 1.9 mm.[14] Most of the grafts in the current study were 10 mm or larger in diameter. As a result, SFPV provides a comparable size match with SSVG without the need for complicated spiraling and is readily available in lengths adequate for longer bypass grafts.

The SSVG is not as durable as ePTFE bypass grafts for intraabdominal venous reconstruction.[10,11] The inferior patency rate may be related to problems with patient selection, competitive flow through large venous collateral vessels, or the length of a compressible conduit exposed to intraabdominal pressure. These factors favor occlusion of SSVG bypass grafts in the abdomen. We have successfully used the SFPV to replace the left renal vein. Renal function was preserved, and the graft remains patent despite the lack of chronic anticoagulation or antiplatelet therapy, exposure to intraabdominal pressure, and the weight of the abdominal viscera. However, the possibility of using longer intraabdominal vein bypass grafts with SFPV for durable relief of vena cava or iliac vein obstruction requires exploration. The availability of long segments of SFPV that are capable of bypassing the entire infrarenal vena cava to the femoral level may prove invaluable in reconstructing anatomically remote sites.

Palliative internal jugular vein reconstruction after bilateral radical neck dissection for malignancy in which both jugular veins are sacrificed remains controversial.[9,23,24] Massive facial edema is common, but the distinction between lymphatic congestion and venous hypertension as the cause of the swelling is unclear. Staged resection may allow venous or lymphatic collateral vessels time to develop, but this is less desirable from an oncologic perspective. Regardless of the precise origin, the edema is associated with considerable morbidity and may be severe enough to cause intracranial hypertension and death. Consequently, jugular venous reconstruction has been advocated in patients who require bilateral radical neck dissections to reduce venous hypertension and related complications.[9,23,24] The experience of Comerota et al.[9] confirmed that carefully selected patients with venous hypertension determined by venous stump pressure measurements will benefit from unilateral internal jugular vein interposition grafting. Their overall patency rate was 64% with 2 to 18 months of follow-up. The majority of graft failures occurred in bypass grafts that were created using ePTFE. SFPV internal jugular replacement is a useful option for simultaneous bilateral radical neck dissection that requires bilateral jugular vein resection. Successful internal jugular reconstruction using SFPV has been reported by others.[23,24] The SFPV graft more closely approximates the diameter of the internal jugular vein than a saphenous vein graft. This size match allows autologous reconstruction in contaminated fields.

Central venous stenosis of the axillosubclavian veins in patients who are undergoing chronic hemodialysis is common.[25] The frequent placement of large-caliber dialysis access catheters in the subclavian veins is the cause of this problem.[3,25,26] The longevity of upper extremity hemodialysis arteriovenous shunts and fistulae may be reduced by outflow stenosis or occlusion of the subclavian veins. In addition, asymptomatic subclavian obstructions can result in venous hypertension and upper extremity phlegma-

sia after placement of chronic arteriovenous angioaccess in the affected arm. The recognition of these stenoses as a cause for dialysis graft failure and upper extremity edema prompted the development of various techniques to correct the stenoses or circumvent them.[3,6,26-28] As our case demonstrates, these patients have exhausted multiple access sites, and preservation of functioning dialysis access remains an important priority. Endovascular interventions with intraluminal stent placement within the subclavian vein compare favorably with surgical bypass procedures.[26] However, when percutaneous techniques fail, surgical bypass grafting may be the only option in salvaging the dialysis access. Internal jugular vein–to–subclavian vein transposition has the advantages of being all-autologous and requiring only one anastomosis.[27,28] However, we favor SFPV graft interposition grafting to this procedure because it allows preservation of the internal jugular vein for venous access in the future and may have better patency rates. The size match between the SFPV and the subclavian vein is excellent, allowing creation of a large venous outflow tract without the use of prosthetic material.

The multitude of venous obstructive syndromes is reflected in the great variety of venous reconstructions. Treatment options must be individualized to meet specific anatomic and physiologic conditions. In this regard, the versatility of the SFPV as venous conduit is its great strength. The unusual case of cavernous sinus thrombosis and dural arteriovenous malformation typifies the need for adaptability. Sagittal sinus–to–jugular bypass grafting with saphenous vein grafts has been used successfully in Japan and France to reduce intracerebral pressure in patients who have cavernous sinus thrombosis.[29,30] The young age and small greater saphenous veins in our patient necessitated the use of SFPV for venous bypass grafting. The size and length proved ideal for this purpose.

The frequent early failure of interposition saphenous vein grafts used for repair of traumatic venous injuries remains a problem; early failures are estimated to occur in 59% to 75% of grafts within the first week.[31,32] Some have attributed these failures to a lack of suitable conduit of adequate diameter.[33,34] Aitken et al.[33] have even suggested that panel saphenous vein grafts should be attempted in all patients who have major venous injuries. The use of SFPV autografts in the reconstruction of traumatic venous injuries has not been previously described. In our case, the contralateral SFPV provided an excellent large-diameter conduit for common femoral vein reconstruction. We thought that ligation alone would have severely impaired the venous outflow to the lower extremity because of the location and magnitude of the injury. The SFPV was readily available and was harvested without significant added operative time.

The applications of SFPV grafts as alternative conduit for arterial reconstructions have been widening. Long-term objective follow-up has supplanted anecdotal reports of minimal lower extremity venous morbidity after removal of the SFPV.[14-16,35,36] The lack of significant late venous swelling and symptoms have increased the enthusiasm for the use of this vein as acceptable autologous conduit. The broad application of major venous reconstruction with SFPV grafts in our patients attests to the versatility of the conduit. Unfortunately, this versatility may have significant limitations. Patients who are plagued by obstructive iliofemoral venous disease and postphlebitic changes from chronic deep venous thrombosis in the axial veins of the lower limb may experience severe donor limb morbidity after removal of the SFPV. Therefore, we do not recommend removing the SFPV in patients who have chronic lower extremity venous insufficiency.

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Submitted Feb. 24, 1997; accepted May 6, 1997.