Femoral vein transposition for arteriovenous hemodialysis access: Improved patient selection and intraoperative measures reduce postoperative ischemia

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Purpose: **Construction of prosthetic arteriovenous access for hemodialysis in the thigh results in a high incidence of graft failure and infection. Autogenous femoral artery–common femoral thigh transposition (transposed femoral vein [tFV]) arteriovenous accesses have superior patency, but our previous report documented a high incidence of ischemic events requiring secondary surgical intervention. Recent results of improved patient selection and intraoperative maneuvers to reduce ischemia are unknown.**

Methods: **During a 6-year period eight children (mean age, 13.3 years) and 46 adults (mean age, 52.3 years; 27 female, 19 male) underwent construction of 55 tFV thigh accesses for hemodialysis access. Adult patients were divided into groups I and II on the basis of the introduction of specific strategies to reduce the incidence of ischemic complications. In the cohort of children, steal prophylaxis included one banded femoral vein, three tapered femoral veins, two distal femoral artery pressure measurements taken before and after access construction (mean ratio, 0.70), and two closed anterior and superficial posterior compartment fasciotomies. Of the first 25 accesses in adults (group I, mean age, 55.9 years), 10 had access banding (six at the initial procedure and four in the immediate postoperative period to treat ischemia). Of the second 22 accesses (group II, mean age, 48.2 years), steal prophylaxis included 14 tapered femoral veins, 6 distal femoral artery pressure measurements (mean ratio, 0.76; range, 0.62 to 0.86), and 1 fasciotomy. Patients with significant distal occlusive disease were not offered a tFV access in the time frame of group II.**

Results: **Eight accesses in children had 100% primary functional patency at 2 years, with no reoperations for ischemia. Nine group I adult patients underwent remedial procedures to correct distal ischemia. No adult patient in group II required a remedial procedure to correct ischemia. Groups I and II 2-year secondary functional access patency was 87% and 94%, respectively. There were no access infections in either group. Femoral vein tapering significantly reduced the need for remedial correction of ischemia (*P* = .03).**

Conclusions: **Improved patient selection and selective intraoperative femoral vein tapering eliminated remedial procedures to correct ischemia in patients undergoing tFV access. Patency rates were excellent despite the liberal use of vein tapering. Transposed FV access should be considered for good risk individuals undergoing their first lower extremity access. (J Vasc Surg 2005;41:279-84.)**

Our recent report of 25 autogenous superficial femoral–common femoral thigh transposition (transposed femoral vein [tFV]) arteriovenous accesses for hemodialysis indicated a 2-year secondary patency rate of 87%, minimal morbidity from edema, and no access infections.[1] Nine of our first 26 patients, however, developed an ischemic complication requiring remedial surgical intervention. In an attempt to reduce the incidence of postoperative ischemic complications in subsequent patients, we excluded patients with distal occlusive disease and initiated prophylactic intraoperative measures to avoid ischemia, yet maintain good patency rates. This report compares outcomes of both patient cohorts to determine the efficacy of these measures.

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PATIENTS AND METHODS

Between March 1998 and December 2003, 54 patients underwent elective construction of 55 tFV accesses for hemodialysis. One patient had bilateral procedures. Follow-up was completed through July 2004. All candidates for the procedure were deemed to have exhausted or have a specific contraindication to an upper extremity access. Preoperative studies in selected patients included ankle-brachial indices and femoral vein duplex ultrasound scanning. The basic technique of tFV access construction is described in our initial publication.[1] Briefly, the femoral vein, in continuity with a variable length of supragenicular popliteal vein, is mobilized from the popliteal fossa to the junction of the femoral vein with the profunda femoris vein. The vein is transposed superficially, analogous to an autogenous brachial-basilic upper arm transposition (basilic vein transposition), and implanted on the distal femoral artery between the divided adductor tendon and the inferior border of the sartorius muscle.

Patients were divided into two groups on the basis of the introduction of specific strategies to reduce the incidence of ischemic complications. In group I (n = 26,

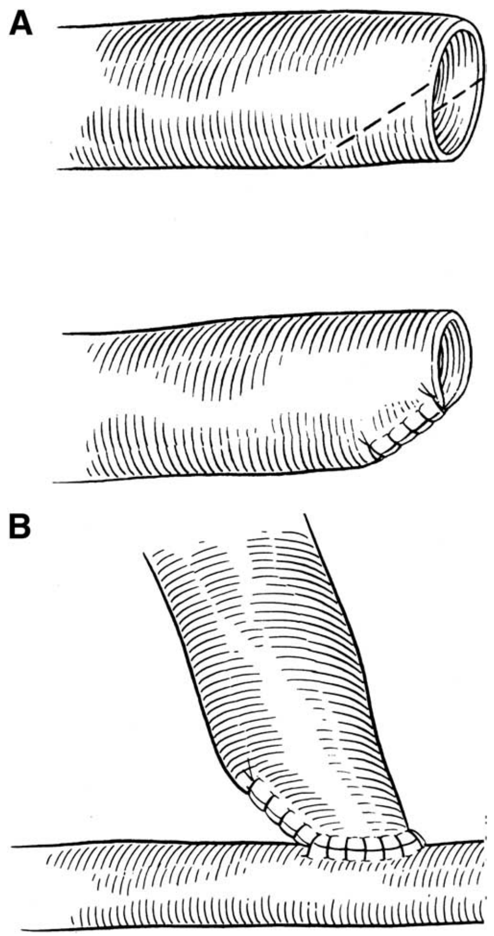

Fig 1. In selected cases, the femoral vein is tapered to a 4.5- to 5.0-mm diameter (**A**) before implantation on the distal femoral artery (**B**).

March 1998 to July 2000) the measures used to avoid postoperative ischemia in selected individuals were access banding and, in individuals with arterial occlusive disease, either origination of the access from the distal end of a prosthetic femoropopliteal bypass graft or construction of a composite prosthetic-femoral vein femoral inguinal looped access. Group I includes the 25 originally published patients along with the twenty-sixth patient in the series. In group II (n = 29, August 2000 to July 2004) we excluded individuals with significant arterial occlusive disease (a requirement for a sequential or composite access, absent pedal pulses, or an ankle-brachial index of <0.85) and individuals who were both old and frail. Intraoperative measures used to avoid postoperative ischemia in selected group II individuals included tapering of the femoral vein at the takeoff from the distal femoral artery (Fig 1), closed anterior and superficial posterior compartment fasciotomies when pulses were very weak or absent immediately after access construction, and measurement of proximal popliteal artery pressure after access construction. The ratio of this pressure to that obtained with the access temporarily occluded provides an index of access-induced pressure reduction. A value of 0.6 was accepted as not likely to induce clinical ischemia. For each tFV candidate, the decision whether to use one or more intraoperative measures to avoid postoperative ischemia was left to the surgeon's discretion.

We generally followed the recommended Vascular Society reporting standards for arteriovenous hemodialysis access surgery.[2] An access requiring polytetrafluoroethylene (PTFE) to maintain patency or relieve ischemia was considered secondarily patent if both hemodialysis access needles could be placed in the femoral vein. Access abandonment was recorded as failure of secondary patency. The main outcomes studied were primary and secondary functional access patency, as well as freedom from remedial surgery to treat a postoperative ischemic complication (pedal ischemia, a compartment syndrome, or ischemic monomelic neuropathy). Patients with ipsilateral below knee amputations were excluded from analysis of reoperation for ischemia.

The outcomes in children (age, <21 years; n = 8) were analyzed separately to provide meaningful results for the more commonly encountered adult hemodialysis population. Thus, group I was left with 25 adult accesses and group II with 22 adult accesses.

Patient characteristics and comorbidities, as well as other comparisons between groups, were analyzed with the Fisher exact test or Student *t* distribution. Kaplan-Meier curves were constructed for primary and secondary functional patency, as well as for freedom from reoperation for ischemia. The log-rank statistic was used to compare group I and II survival curves for primary and secondary patency, and freedom from reoperation for ischemia, and to compare tapered and nontapered accesses for effectiveness in avoiding reoperation for ischemia. A Cox proportional hazards regression was used to identify factors possibly contributing to access failure and reoperation for ischemia.

The Cedars-Sinai Medical Center Institutional Review Board approved this study (4460-01).

RESULTS

Tables I and II outline patient characteristics and comorbidities for all patients.

Children. Of eight children, one had femoral vein banding, three had femoral vein tapering, two had closed anterior and superficial posterior compartment fasciotomies, and two had access induced pressure ratios of 0.68 and 0.75. The 2-year primary and secondary functional access patency was 100%, with no reoperations for ischemia. One child developed a lymphocutaneous fistula that was closed surgically 3 weeks after access construction.

Adults. Although group I adult patients had proportionally greater women, diabetics, older patients, and composite accesses than those in group II, none of these differences was significant.

No patient in the time period of the first 25 adult patients (group I) was excluded solely because of distal occlusive disease. Twenty of these patients had straight

Table I. Clinical characteristics of patients who had femoral vein transposition for hemodialysis access created in two successive time intervals

	Group I (*n* = 26)	*Group II* (*n* = 29)	P *value*
Children (n = 8)	1	7	
Age (mean, y)	19.0	12.4	
Adults (n = 47)	25	22	
Age (mean, y)	55.9 ± 3.0	48.2 ± 2.9	.08
Female/male	18/7	10/12	.08
Diabetes mellitus	15 (60%)	7 (32%)	.08
Ipsilateral amputation	3 (12%)	1 (4%)	.61

Table II. Comorbidities of two groups of adults (n = 47) who had creation of a femoral vein transposition access for hemodialysis

	Group I (*n* = 25)	*Group II* (*n* = 22)	P *value*
Option of placing access in either leg (%)	44 (11)	91 (20)	.0008
Composite tFV-PTFE access created at initial surgery (%)	20 (5)	0 (0)	.05
tFV banded at initial surgery (%)	36 (9)	0 (0)	.001
tFV tapered at initial surgery (%)	0 (0)	64 (14)	<.0001

femoral vein accesses originating on the distal femoral artery. Five had either a composite femoral vein–prosthetic looped (4) or sequential (1) access originating on the common femoral artery. Ten accesses were banded either intraoperatively (6) or in the immediate postoperative period (4) to avoid or treat ischemia. Nine patients manifested evidence of ischemia in the postoperative period (distal ischemia, 6; compartment syndrome, 2; ischemic monomelic neuropathy, 1). Procedures to alleviate ischemia included various combinations of distal bypass without interval ligation, conversion to a looped access, iliac artery angioplasty, fasciotomy, access banding, and access ligation. One individual eventually had an above knee amputation. Three banded accesses lost primary patency in the follow-up period.

In the time period of the subsequent 22 adults (group II), patients lacking pedal pulses were not considered for a tFV access. None of the group II patients had access banding. There were 14 tapered femoral veins, 1 closed anterior and superficial posterior compartment fasciotomy, and 6 measurements of distal femoral artery pressure, all but one in accesses that were tapered (mean, 0.75; range, 0.62 to 0.86). No patient required a remedial procedure for ischemia. No tapered access lost primary patency in the follow-up period. There were no major wound complications or graft infections in the adult group II.

Kaplan-Meier functional patency curves for groups I and II are shown in Figs 2 and 3. Although there is increased primary and secondary access patency in group II, the differences are not significant. There is, however, a significant difference between groups (Fig 4) when reoperation for ischemia is considered (P = .001). The Cox regression identified no characteristic or comorbidity affecting functional access patency or reoperation for ischemia. Compared to nontapered accesses, tapered accesses significantly reduced the incidence of reoperations for ischemia (P = .03). The difference in access thrombosis between banded and tapered accesses is also significant (P = .05).

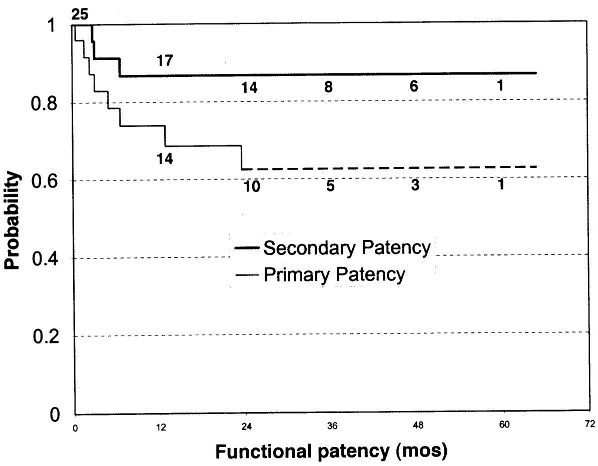

Fig 2. Kaplan-Meier primary and secondary functional patency curves for adult patients in group I.

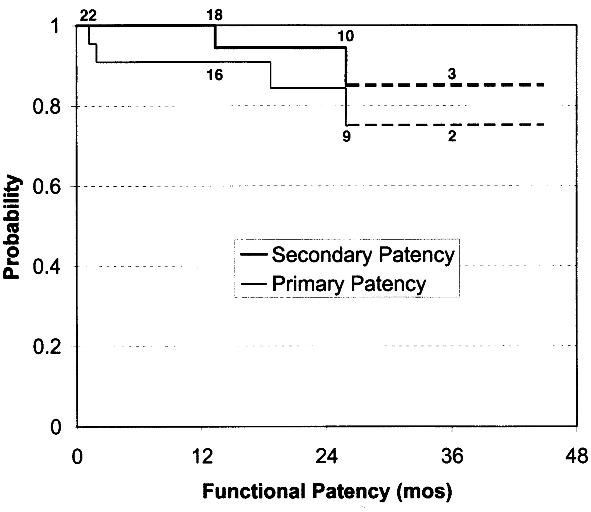

Fig 3. Kaplan-Meier primary and secondary functional patency curves for adult patients in group II.

DISCUSSION

National Kidney Foundation-Dialysis Outcomes Quality Initiative clinical practice guidelines first published in 1997[3] discouraged subclavian vein catheters and advocated

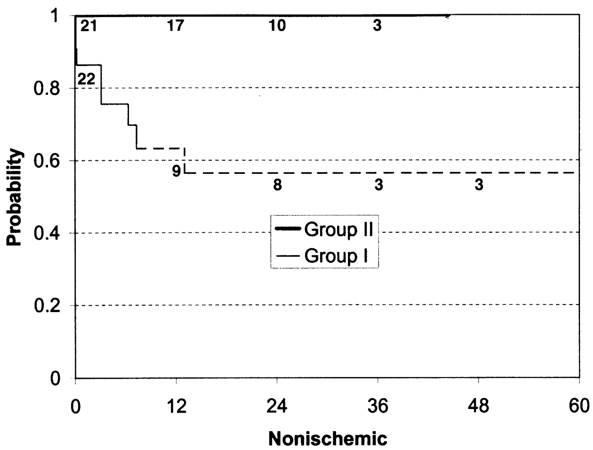

Fig 4. Kaplan-Meier curves for freedom from reoperation for ischemia for adult patients in groups I and II.

increased construction of upper extremity autogenous vein fistulas, each of which should result in a reduced need for lower extremity access construction. Nonetheless, in our large urban population (greater Los Angeles), where surgical skills vary widely and prosthetic access construction is still the norm, a small but stubborn percentage of patients eventually require lower extremity access. Most of our patients had their initial accesses placed in other communities.

When upper extremity access is exhausted, most surgeons construct a prosthetic inguinal looped access.[4-9] A recent landmark study of these accesses by using the standards recommended by the Vascular Societies reported 2-year primary and secondary patency rates of 19% and 54%, respectively, an overall infection rate of 41%, and an 11% incidence of ipsilateral limb ischemia.[9] Reports of access construction with cryopreserved veins and bovine mesenteric bioprosthetic grafts show some outcomes improvement over PTFE,[10,11] but not attaining the high levels of patency and freedom from complications seen with autogenous vein in the upper extremity.[12] Saphenous vein accesses are occasionally successful,[13] but in our experience, the saphenous vein is an unreliable conduit because of its relatively small size and unfavorable position for transposition.

Our original report of 25 tFV accesses showed good functional 2-year primary and secondary patency rates but an alarming incidence of ischemic complications requiring reoperation.[1] Rather than abandon the procedure entirely, we identified four factors possibly responsible for the increased incidence of ischemia compared to an inguinal looped or arm access, and we initiated appropriate measures to mitigate them, beginning with the twenty-seventh patient in our series.

One factor contributing to ischemia might relate to the initiation of the access on the distal femoral artery rather than in the groin.[14] Unfortunately, there is rarely sufficient femoral/popliteal vein to loop back to the common femoral artery, and we believed that lengthening the access with PTFE would defeat the advantages of an all-autogenous access. Neither of these procedures was considered for group II patients.

The second factor contributing to the relative increase in ischemic complications, especially when comparing a tFV to upper extremity accesses, is the increased prevalence of arterial occlusive disease and calcification (stiffness) in lower extremity vessels. Although this factor does not explain why ischemic steal is infrequently seen when constructing a prosthetic inguinal looped access, it did suggest that one prudent measure to reduce ischemic complications would be to exclude individuals with significant arterial occlusive disease.

Vascular surgeons commonly encounter compartment syndromes in the setting of ischemia-reperfusion. A recent study of fasciotomy after femoral vein harvest for complex vascular reconstruction suggested that the compartment syndromes result from combined ischemia-reperfusion and venous hypertension.[15] Two of our group I patients experienced a postoperative compartment syndrome after tFV construction, suggesting that a combination of "steal" ischemia and venous hypertension alone, without reperfusion, is sufficient to develop a compartment syndrome.[16] We further reasoned that increased postoperative ischemia might enhance the likelihood of a compartment syndrome, and therefore we performed prophylactic closed anterior and superficial posterior compartment fasciotomies in three group II patients with marginal or absent pulses immediately after tFV construction. We did not, however, measure compartment pressures in patients having either prophylactic or therapeutic fasciotomies.

The fourth factor relates to conduit size mismatch between artery and vein.[17] In a nontransposed arteriovenous fistula, an increase in fistula anastomotic diameter greater than the diameter of the proximal artery does not appear to increase fistula flow.[18] On the other hand, access flow does increase in bridge grafts when the diameter of the bridge graft exceeds the diameter of the proximal artery.[19] In this regard, the tFV resembles a bridge graft. Because the distal femoral vein is frequently 8 mm or larger, we addressed this issue by tapering the femoral vein to a diameter of 4.5 to 5 mm before implanting it on the femoral artery.[20] Preimplantation access tapering reduces flow while maintaining access patency more reliably than postconstruction access banding.[20,21] Vein tapering was not used when the femoral vein was relatively small compared to the femoral artery. Our initial success in preserving distal pulses and avoiding postoperative ischemia persuaded us to use this prophylactic measure in 17 group II patients.

In addition to introducing specific prophylactic measure based on these four factors, we also monitored popliteal artery pressures before and after temporary occlusion of the newly constructed access in selected patients as described by Knox et al.[22] Because previous clinical studies suggest development of the steal syndrome is rare with a pre/post compression ratio of >0.50,[19,21] we arbitrarily selected a cutoff ratio of 0.60 as a level not requiring additional measures to reduce the likelihood of postoperative ischemia.[19,22] All eight patients tested in this fashion had a ratio of greater than 0.60.

We elected to analyze the results of children separately from those of adults, because most vascular surgeons do not provide access for this cohort, and children are not vulnerable to the potential confounding contribution of arteriosclerotic occlusive disease to ischemia. The primary and secondary patencies and complete freedom from ischemic complications and infection in this cohort suggest that tFV is superior to a prosthetic conduit in children who cannot have upper extremity access.[23]

With a functional secondary 2-year patency rate of 94% and complete freedom from ischemic complications, the adults in group II fared better than those in group I, as well as those in other published studies of prosthetic inguinal looped grafts.

The complete absence of access infection in the overall series of 55 accesses contrasts strikingly with other series[4-9] (11% to 41%) reporting prosthetic inguinal looped accesses. When fistula revision with PTFE was used to maintain access patency or correct ischemia, we deliberately tunneled the PTFE deeply, obliging technicians to cannulate only the more superficially placed femoral vein. We believe that access infection results from frequent cannulation of PTFE.

The shortcomings and limitations of our study merit discussion. Both our original series and the present study are retrospective analyses of our experience with tFV. The procedure was introduced to treat a specific population of patients, namely those who require a new lower extremity access. We believe that population has changed somewhat during the 6 years we have undertaken this study. The early patients, often the product of numerous failed lower extremity accesses, were sicker and older than our later patients, in whom tFV was more frequently done as the individual's first lower extremity access.

Furthermore, the sex and diabetic status of our group II adult patients are notably but not significantly different from our group I patients. We believe these differences, each seemingly favoring the group II patients, are entirely coincidental and not due to a subtle bias in patient selection.

Our reassessment of the operation after the twenty-sixth patient resulted in introduction of several promising measures to reduce ischemia. The use of any given measure, however, was always at the discretion of the surgeon, because it was not known which, if any, of these measures would prove effective. In such an exploratory study without controls and specific guidelines, it is difficult to establish the efficacy of any single measure, especially because multiple measures were used in some individuals. In retrospective analysis, only vein tapering emerges as a strong candidate for additional study and possible verification of efficacy. It should be noted that the decision whether to taper a femoral vein in group II was not always a random event, because some veins were considered relatively small and some arteries were relatively large. In each instance in which access tapering was not used, however, the surgeon guessed correctly that a steal would be unlikely.

The potential benefit of fasciotomy is unknown—in part because only three patients had the procedure, and in part because the pathophysiology of compartment syndrome development in our two group I patients remains poorly understood. Likewise, the role of intraoperative pressure measurement remains unclear, because the premise that a ratio <0.60 is unacceptable remains untested. For anyone choosing to measure these pressures, however, it should prove comforting to find a ratio >0.60.

Direct comparison between the outcomes of our group II accesses and those of other studies is also limited. We rejected a small but not prospectively tallied number of candidate patients because of arterial occlusive disease and frail old age. These patients underwent a prosthetic inguinal looped access instead.

The relatively small group sizes under study limit the power of our conclusions, especially after the cohort of children is removed from our comparison of groups I and II. Nevertheless, we believe that the mere knowledge of potential ischemia during the time frame of group II led us, and could lead others, to increased intraoperative vigilance and selective use of effective measures, especially vein tapering, to prevent postoperative ischemia.

In conclusion, a tFV access can be constructed with excellent patency and minimal ischemia and infection. It should be considered the first choice for lower extremity access in good risk individuals.

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DISCUSSION

Dr Ronald Webb (Oakland, Calif). This study covers 6 years of difficult work. Dr Gradman used what he learned from group 1 to improve his results in group 2. The audience should recognize that there are eight children in this series. Adult patients should have palpable pedal pulses or ankle-brachial indices greater than 0.85 to get good results. The large femoral vein was tapered to avoid steal in 14 of the 22 patients. Of note, no graft in either group 1 or group 2 was removed for infection. Dr Cull found 41% of his femoral PTFE grafts were infected in the longest study in the literature. I have three questions for Dr Gradman. First, would you transpose the femoral vein to the upper extremity if a basilic vein target were available? Second, would you share your technique of revision and thrombectomy of the femoral vein graft with the audience? Third, do you have any idea of how many patients you evaluated but excluded before performing the femoral vein transposition in the second group?

Dr Wayne S. Gradman. Thank you, Dr Webb. We don't transpose the femoral vein to the upper extremity as Dr Huber does. Basically, we don't want to harm two extremities at once. We would rather exhaust the upper extremities with PTFE before moving to the lower extremity. On the other hand, we don't do necklace grafts, ax-fem grafts, or grafts to the jugular vein.

Thrombectomy and access revision is an interesting issue. Clotted basilic and cephalic vein accesses are very difficult to open and keep open. It's a lot easier in the lower extremity with the femoral vein. The femoral vein is a big conduit and you are accessing it using only a quarter of its circumference, so that when you actually need to clean one out, you usually find that the body of the access is quite disease-free. The problem is usually at either the arterial anastomosis or at the junction of the femoral vein and the common femoral vein, and about half the time those problems can be treated either with balloon angioplasty or interposed PTFE. At the arterial end, where reoperation can be a bit challenging, I often just disconnect the vein and create a composite loop back to the common femoral artery. That's actually a fairly simple operation. At the venous end, I have patched the femoral vein stenosis with a double width of saphenous vein (rather than spiral vein) to maintain the large lumen size.

Finally, the issue of how many patients we evaluated but excluded is important, since it makes any comparison of our series to those of Drs Cull and Glickman a bit problematic. We don't believe this operation is for everybody. However, in the second group I personally performed the operation in over 20 patients and I excluded only two patients. My two colleagues and coauthors, however, are not database keepers, so I can't tell you our exact numbers. Surprisingly, most candidates we evaluate have pedal pulses.

Dr Gregory L. Moneta (Portland, Ore). Dr Gradman, do you look at the femoral vein ahead of time with duplex scanning to ensure that it hasn't had a previous thrombus before you do this procedure?

Dr Gradman. Yes, we always try to scan the femoral vein for size, DVT, duplications, et cetera before we use this procedure. But we've been burned a couple of times with unexpected iliac vein disease.

Dr Ronald Dalman (Stanford, Calif). Are there any tricks to tunneling the femoral vein?

Dr Gradman. Yes, there are. I make two counterincisions to facilitate the tunneling and to try to avoid acute angles at either end. Between these two counterincisions is where the vein will be accessed. You don't need much length between those incisions, about 15 centimeters is OK. It is interesting that all the wound complications we experienced involved necrosis on the medial flap of the incision, never on the lateral one, so I feel comfortable keeping the vein within 2 or 3 centimeters of the main incision. That way I conserve length, particularly in obese patients, where every millimeter counts.