Axillary Vein Valve Transplantation in Patients with Advanced Chronic Venous Insufficiency: Long-Term Valvular Competence and Clinical Success

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ABSTRACT **Axillary vein valve transfer is a useful technique of valve reconstruction. It is the mainstay for reconstructing postthrombotic vein segments in which valve structures have been destroyed beyond repair. The technique may appear deceptively simple, but in fact it requires meticulous execution to be successful. Clinical results using the technique are similar to those obtained with direct valve repair techniques. The results of axillary vein transfer in postthrombotic syndrome are similar to those obtained in "primary" reflux with actuarial recurrence-free survival of >60% at 6 years. Deterioration in function as demonstrated by duplex competence is the main cause of clinical recurrence. Most of these failures occurred during the first 3 years after surgery, with the survival curves remaining stable thereafter.**

Keywords **Axillary valve, valve reconstruction, postthrombotic syndrome**

The first cases of clinical axillary vein valve transplantation in the management of chronic venous insufficiency were simultaneously reported by Raju and Taheri in 1980.[1] Additional series by these[2-4] and other authors[5-7] have since appeared in the literature. Preliminary clinical results[4] with this technique appeared to be inferior to those with the direct internal valvuloplasty technique; a number of the transferred axillary valves apparently failed because of dilatation that was attributed to compliance mismatch between the transferred valve segment and the thickened postthrombotic recipient femoral vein. Placement of a prosthetic sleeve around the transferred axillary valve segment was proposed as a possible solution to the problem.[8] Later series incorporating this modification have yielded clinical results for axillary vein transplantation essentially similar to those for direct valvuloplasty techniques.[9] Nonetheless, the transplanted valves appear to deteriorate more rapidly than do directly repaired valves in terms of duplex competence.[9] Furthermore, axillary valve

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transplantation is a more extensive procedure than direct valve repair techniques. Harvestable axillary valves are a limited resource and should be conserved for potential future use in a disease characterized by chronicity, recurrence, and frequent bilaterality. When given a choice, direct valvuloplasty is preferable to axillary valve transplantation for these reasons. Only when direct valve repair is not feasible is axillary vein transplantation a viable and satisfactory option in the treatment of chronic venous insufficiency.

INDICATIONS

The primary indication for axillary valve transfer is severe postthrombotic syndrome in which the endogenous valves in the lower limb have been destroyed beyond repair. Axillary vein transplantation can also be used as a salvage procedure when an attempted direct valvuloplasty ends in technical failure. Even in "primary" reflux, valves are not always present in the expected locations. This is particularly true for the popliteal and profunda femoris locations. Axillary vein transfer is the backup procedure of choice in these circumstances. For these reasons, it is a desirable practice to have one axilla prepared in all valvuloplasty operations. Occasionally all possibilities for direct valvuloplasty may be exhausted owing to premature failure of previously repaired valves. In such "redo" cases, axillary vein transfer is the most attractive option for repeat valve reconstructions.

PREOPERATIVE WORKUP

A complete set of physiological[10] and anatomic studies should be carried out, including a coagulation profile to detect hypercoagulable states; arm/foot venous pressure differential to identify and assess obstruction; ambulatory venous pressure to measure global impairment; airplethysmography as an index of calf venous pump function; and duplex Doppler to identify refluxive segments. Ascending and descending venography provides the degree of anatomic detail that is required for surgical intervention. Preoperative duplex or contrast examination of the axillary brachial veins has been found to be neither useful nor necessary in planning the procedure.

TECHNIQUE

Axillary vein valves have most frequently been inserted at the proximal femoral or popliteal locations. Some surgeons prefer the latter site,[5] as the popliteal vein is considered the "gateway" to the calf venous pump. The author prefers the proximal femoral site because simultaneous reconstruction of the profunda femoris vein can be achieved through the same incision if desired. This may be indicated in postthrombotic syndrome,[9] particularly when varying degrees of "axial transformation" of the profunda femoris vein are present.[11] The dilated profunda femoris vein is invariably refluxive from dilatation in these instances, and the reflux flow drains into the calf venous pump through a large profunda popliteal collateral connection. Mid- and distal femoral locations are also acceptable sites for axillary vein transplantation. These sites are particularly useful in redo procedures in which the primary sites for valve transfer have been exhausted by previous failed valve reconstructions.

Regardless of the site chosen for axillary vein transfer, the recipient venous segment should be carefully inspected for the presence of repairable endogenous valves prior to making the axillary incision for valve harvest. The presence of postthrombotic changes in the exposed venous segment or elsewhere in the limb does not preclude the existence of repairable valves at the exposed recipient site. In our experience, a direct valvuloplasty technique was feasible in postthrombotic venous segments in about 20% of cases.

Exposure and Preparation of Recipient Site for Axillary Vein Transfer

The superficial femoral and profunda femoris veins are exposed through an oblique groin incision. Four to 5 cm of the target venous segment should be cleared of side branches. Perivenous fibrosis of postthrombotic origin is frequently present, requiring sharp dissection to separate the vein from the artery (Fig. 1).

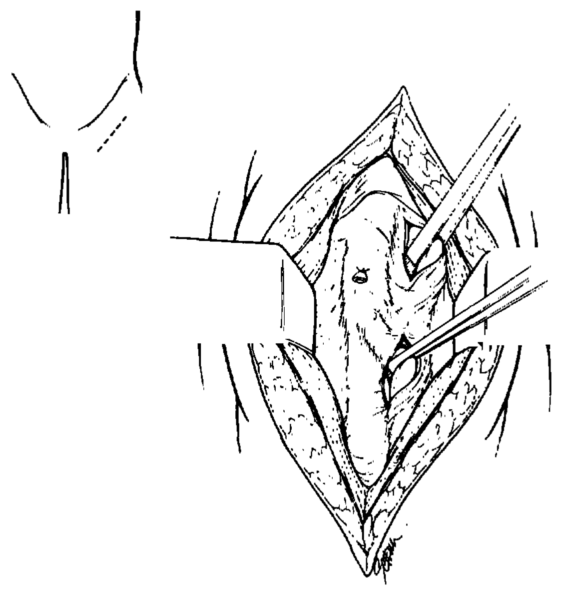

Fig. 1 Exposure of the femoral vein confluence in the groin area. Sharp dissection is necessary when postthrombotic fibrous encasement is present. A 4- to 5-cm length of target veins should be cleared in preparation of axillary vein transfer. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

Mid- and distal superficial femoral veins in the subsartorial tunnel are approached through longitudinal incisions.

The popliteal vein is approached through a medial incision. The medial head of the gastrocnemius is taken down for wide exposure of the tibiopopliteal venous segment. Reattachment of the muscle during closure of the incision is not necessary. A profunda popliteal connection of variable size is frequently present in postthrombotic cases. It may be divided only when superficial femoral outflow is not compromised by postthrombotic changes. The short saphenous and gastrocnemius veins are routinely divided during popliteal vein exposure.

Ancillary Procedures

If the long saphenous vein is refluxive, it should be stripped concomitantly with the axillary vein transfer procedure (Fig. 2). In some cases of postthrombotic superficial femoral vein occlusion, the long saphenous vein may

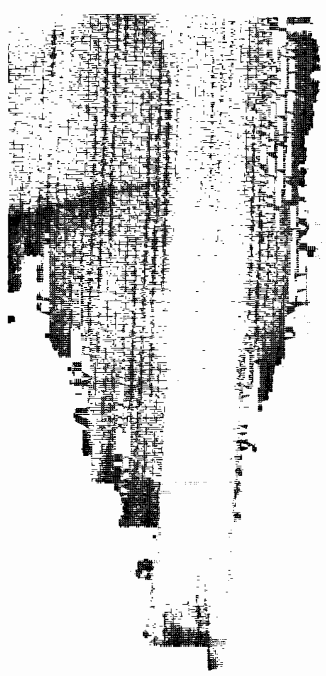

Fig. 2 Venographic appearance in a case of advanced postthrombotic syndrome. Note extensive network of superficial collaterals. The saphenous vein appears to function as the main outflow as the deep veins are not visualized. At exploration, however, the profunda femoris was wide open although trabeculated and refluxive. An axillary vein transfer was carried out to this vein with concomitant stripping of the refluxive saphenous vein. The poorly recanalized superficial vein was divided. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

appear to be enlarged and act as an outflow collateral (secondary varicosity). In some venograms, the long saphenous may even appear as the only available outflow path with nonvisualization of any of the deep veins of the limb. This is invariably a spurious phlebographic artefact due to contrast flow patterns. Despite nonvisualization, adequate deep venous collaterals are apparently present in these cases and the dilated refluxive saphenous vein can and should be excised. This maneuver is not only safe and without malsequelae, but also provides significant benefit to the patient by abolishing an important source of reflux.[12]

Searching for a Repairable Endogenous Valve Prior to Axillary Vein Transfer

The exposed venous segment should be carefully searched for a repairable valve before initiating the axillary valve transfer procedure. Unless it has been destroyed by a previous thrombotic process, the uppermost superficial femoral valve is almost constant in location and presence.[13] It is located in the proximal inch of the superficial femoral vein, just below the profunda orifice. Valves in the profunda femoris and the popliteal are less constant in presence and location. The presence of a valve station bulge helps to localize the area for a valve search but by no means ensures that intact underlying valve cusps will be present. The valve station bulge frequently persists even after the valve cusps have been destroyed, but it is not necessary to open the vein to search for the valve cusps. *The presence of valve attachment lines is a certain indication that underlying valve cusps are present* (Fig. 3). These lines may be visible through the glistening wall of the vein in some nonthrombotic cases. When the adventitia is thick, particularly in postthrombotic cases, deliberate adventitial dissection is required to expose the valve attachment lines.[13] Peeling away the adventitia with diamond jaw forceps, combined with some sharp dissection if necessary, is the most expeditious way to expose the lines. They should be exposed in their entirety from commissural apex to commissural apex. In addition to providing confirmation of valve presence, this is an essential first step in performing many direct valve repair procedures.[13] *The absence of valve attachment lines despite adequate adventitial dissection is an almost foolproof indication that underlying valve cusps have been destroyed.* Under the circumstances, a venotomy should not be performed in a futile search for the nonexistent valve cusps. One should proceed directly to an axillary vein transfer procedure. In some cases, a portion of the valve attachment lines may be absent, usually involving one of the two cusps. Although this generally indicates nonrepairable valve destruction, occasionally such valves have been repairable. For this reason, a quick "trial" valve repair using a rapid technique such as the transcommissural repair is worthwhile when this situation is encountered. If the attempt fails, one can then proceed to axillary vein transfer.

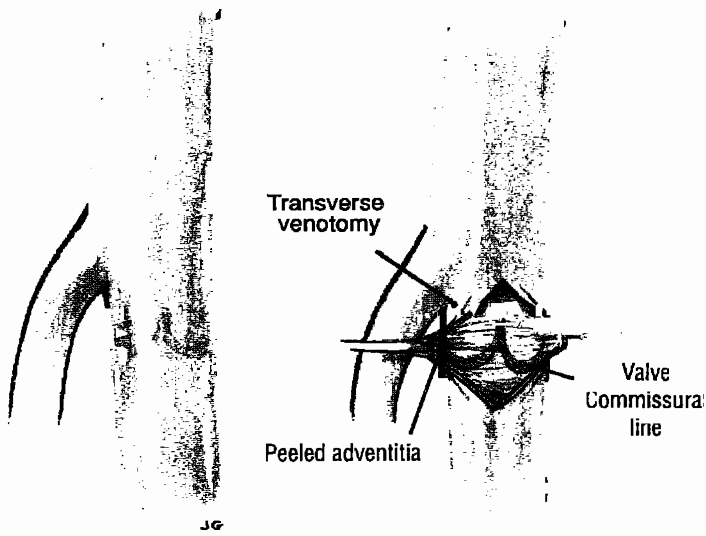

Fig. 3 Exposure of valve attachment lines by adventitial dissection over the valve station bulge. Presence of valve attachment lines in their entirety is certain indication of the presence of valve cusps that can be repaired by direct valvuloplasty. Conversely, the absence of the lines indicates absence of underlying valve cusps. In the latter instance a venotomy is unnecessary to confirm the absence of valve cusps. (From Raju S., Hardy JD. Technical options in venous valve reconstruction. Am J Surg 1997;173:301–307, with permission from Excerpta Medica Inc.)

Exposure and Harvest of the Axillary Vein

One axilla and the upper arm are always prepared for possible use in all venous reconstructive procedures. When the decision is made to proceed with the axillary valve transfer procedure, a transverse incision is made high up in the axilla along the skin crease. The axillobrachial nerve is often in the field and may have to be divided even though every effort is made to save it. Temporary but annoying hypoaesthesia in the medial upper arm that persists for several weeks may result with nerve division. The axillary vein is easily located medial to the artery and dissected out, and a useable valve is sought. In most cases two or three valves in the axillobrachial segment are accessible through the incision. A valve near the first rib is almost always present and approachable through the incision except in the most obese patient. The valve stations become progressively larger moving from the brachial to the axillary vein, so it is usually possible to select a valve that is a good size match for the recipient vein. Several small tributaries must be clipped and divided to isolate the valve and test it for competence. A positive strip test is performed, in which blood is squeezed against the closed valve to test for leakage into the infravalvular segment that has been emptied of blood and clamped off by a bulldog clamp.

In about 30 to 40% of cases, the valve is found to be leaky to some extent.[4,14] Competence can be restored to these valves by performing a transcommissural valve repair (Fig. 4). Two or three transluminal sutures of 7-0 Prolene placed along the valve attachment lines on each side are usually adequate to render competency. Because the transcommissural technique[15] is rapid and is almost always successful in restoring competence, it is the preferred technique in this setting. Other valve repair techniques[14] are either time-consuming (e.g., internal valvuloplasty) or less consistently successful.[15] Repair of leaky axillary valves is best accomplished before harvest in that a distended valve station is required for executing the technique and the valve is spared from harvest in the event of unsuccessful repair. In about 10% of axillary valve transfer procedures, the valve becomes incompetent *after* the transfer procedure is completed, necessitating a transcommissural repair in the transferred position. Occasionally an axillary valve transfer is not feasible, either because a suitable valve is

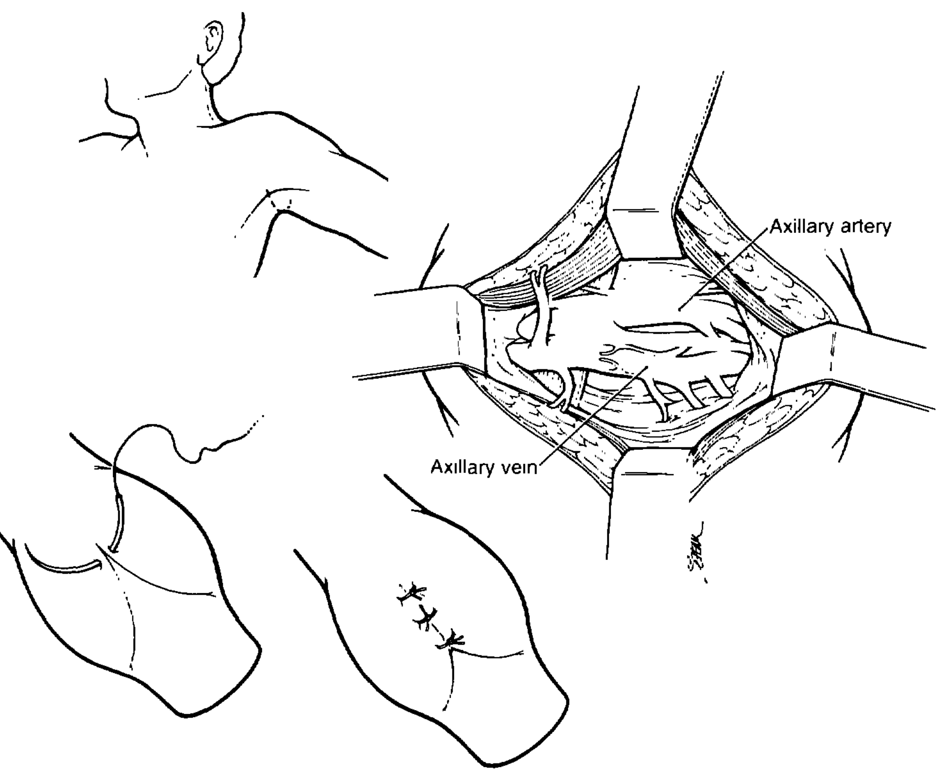

Fig. 4 Exposure of the axillary vein through a transverse incision in the axilla. Repair of a leaky axillary valve by the transcommissural technique is shown. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

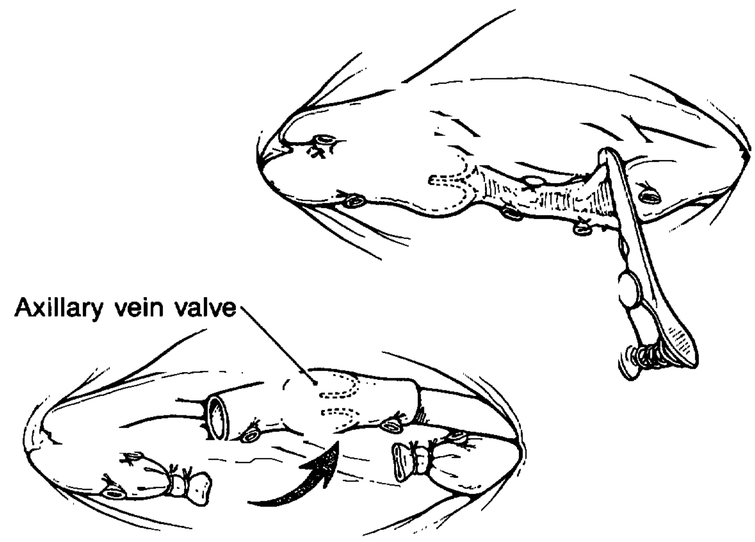

Fig. 5 The axillary valve is tested for competence. A positive strip test (see text) should be employed. The cut ends of the axillary vein are ligated without repair. (From Raju S. Axillary vein transfer for postphlebitic syndrome. In: Bergan JJ, Kistner RL, eds. Atlas of Venous Surgery. Philadelphia: WB Saunders; 1992:147–152; used with permission.)

not present or because attempted repair of a leaky valve is not successful. These patients are candidates for denovo valve reconstruction[13] or cryovalve insertion.

Once an axillary valve has been harvested, the donor axillary vein can simply be ligated at either excised end and need not be reconstructed (Fig. 5). Signs and symptoms of axillary vein outflow embarrassment are virtually nonexistent with ligation. Less than 2% of patients complained of arm swelling, which was mild, episodic, and easily tolerated.

Transfer Technique

The excised axillary valve segment (approximately 3 cm in length) is marked with a pen or clip for proper orientation and placed in ice-cold balanced salt solution until final preparation of the recipient vein segment has been accomplished. A 5-cm length of the recipient venous segment that has been cleared of branches in anticipation of the transfer procedure is now controlled by a traumatic vascular clamp, and a 2-cm segment is excised. The axillary valve is interposed, performing the upper suture line first. Interrupted suture technique is essential, as even the most carefully placed continuous sutures are sure to lead to suture line stenosis owing to intraoperative venospasm and later hydrostatic dilatation of the suture line when the patient assumes the erect position. Continuous suture technique for half the circumference and interrupted sutures for the remainder is an acceptable alternative when the recipient vein is rigid from postthrombotic fibrosis. This tactic is particularly useful in profunda femoris reconstructions in obese patients in whom exposure for placement of the posterior half of the suture line may be limited. When the proximal suture line is completed, the upper clamp is removed and the valve is tested by a positive strip test (Fig. 6). The valve should be totally competent, and even a mild leak should not be tolerated. In case of leakage, the valve must be repaired before proceeding with the lower suture line. The lower anastomosis is crucial, as the axillary valve segment must be adjusted for proper tension and axial orientation without torsion. Even the slightest errors in this technical phase can result in leakage of the transferred valve. Tension is adjusted by trimming the recipient and/or the donor vein. Leakage of the valve should be monitored with the desired tension applied to the valve before the actual trimming is done. Torsional orientation is equally important and it is helpful to mark opposite points in the circumference of the vein before the harvest. The lower suture line technique is similar to that of the upper suture line. After completion of the lower suture line, the valve must be tested again for leakage by positive strip. Once competence is assured, the valve is wrapped by a ringed PTFE sleeve of appropriate size (usually an 8- or 10-mm graft). The

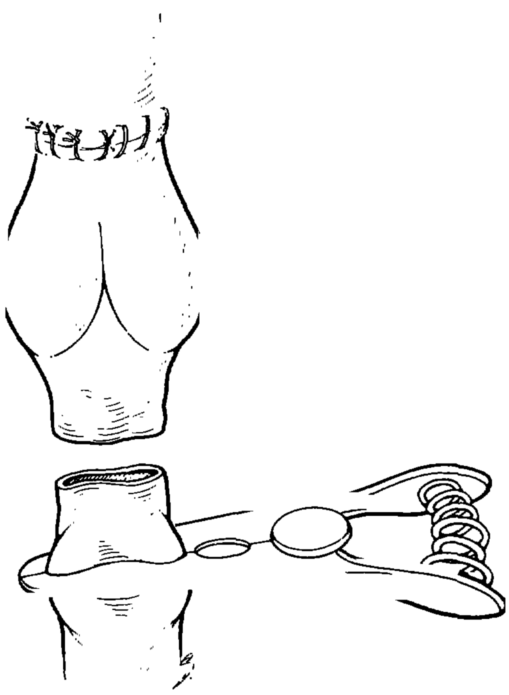

Fig. 6 Testing the valve for competence after the upper suture line has been completed. Interrupted sutures should be used for at least half the circumference of the anastomosis. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

Fig. 7 Axillary vein transfer. A ringed PTFE sleeve is being applied around the transferred valve to prevent late dilatation. It is better to apply the sleeve after completion of the lower suture line and testing the valve for competence. It is crucial that proper tension and rotational orientation of the axillary vein graft must be ensured before starting the lower suture line. Even seemingly minor technical deficiencies in this area can result in de novo valve incompetence. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29: 1050–1064, Mosby-Year Book, Inc., with permission.)

sleeve graft (about 2 cm in length) is split open and sewn back together around the valve with interrupted or continuous 5-0 Prolene sutures (Fig. 7). One or two sutures anchoring the sleeve to the adventitia of the valve station will prevent migration. The incision is closed with a suction drain.

Although it is somewhat easier to slip the unsplit sleeve graft over the transferred axillary valve before starting the lower suture line, rather than sewing it around the valve as the last step, we have found it more difficult to assure accurate rotational orientation of the valve and carry out a positive strip test with the sleeve already in place. The sleeve is thought to be helpful in preventing dilatation of the transferred axillary vein segment from compliance mismatch and exposure to higher hydrostatic pressure than is present in the upper limb. The technique of axillary vein transfer has been provided in some detail here because, although it may appear rather simple, it is in fact quite demanding. Minor technical imperfections that may be tolerated in the high velocity flow of the arterial system are less well tolerated in the low velocity venous system of the limbs. Despite exacting technique, approximately 20% of axillary valve transfers become incompetent within the first year.[9]

Technical Variations

Anatomic variations that are frequently present in the axillary brachial veins may require modification of the standard technique. Frequently a large basilic vein containing a valve joins a valved brachial vein in the upper arm. When this configuration is available for harvest, size disparities in which the axillary brachial vein segment is smaller can be corrected by joining the valved basilic and brachial veins together at the lower end to form a single lumen. An inverted valved Y conduit can be utilized to reconstruct the entire femoral confluence, restoring competence to both superficial femoral and profunda femoris veins (Fig. 8). Additional technical variations that can be utilized depending

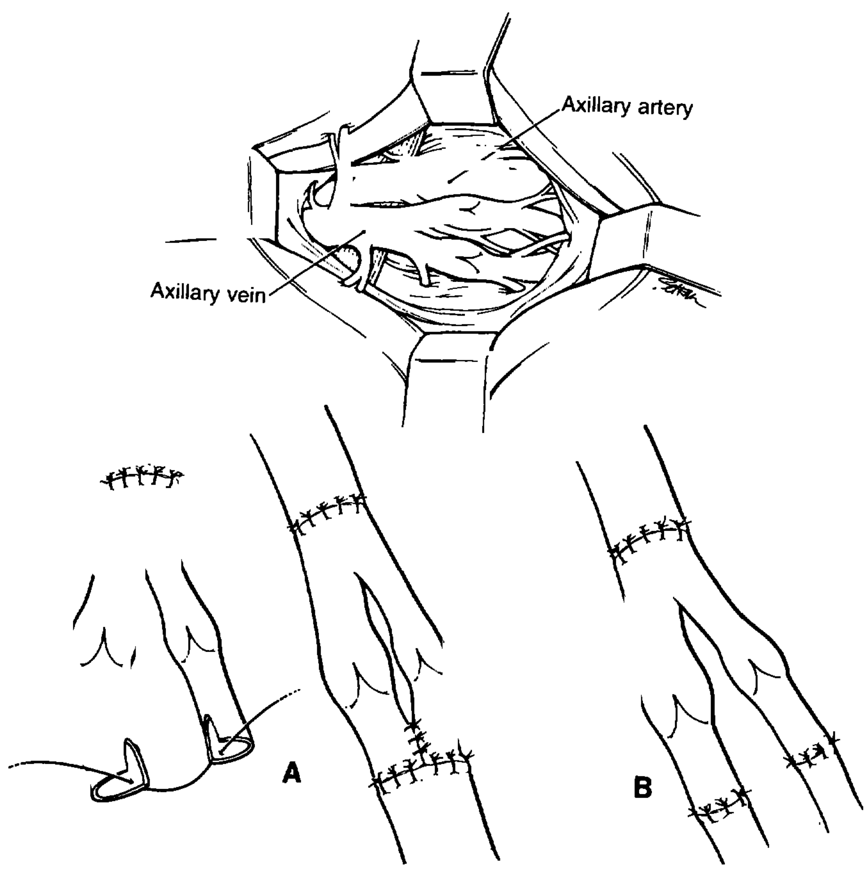

Fig. 8 Axillary vein transfer, technical variations. A valved basilic and brachial vein combination can be used to address size disparities (**A**) or reconstruct the entire femoral confluence restoring valve competence to both the superficial femoral and profunda femoris veins (**B**). (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

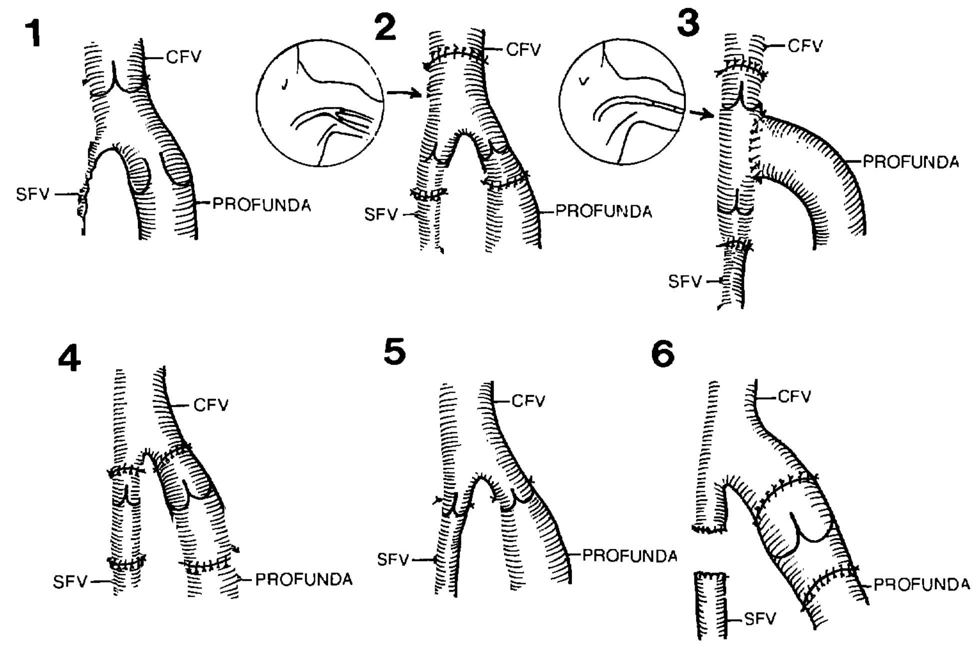

Fig. 9 Technical variations in valve reconstruction of axillary transformed (partial or complete) profunda femoris vein. 1. Common femoral veins (CFV) valvuloplasty as a proxy profunda valve repair. SFV, superficial femoral veins. 2. Axillary vein transfer to superficial femoral and profunda veins with use of bifurcating axillary veins. 3. Repair of superficial femoral and profunda femoris veins with two sequential valves in the axillary vein. 4. Two separate axillary vein transfers to profunda femoris and superficial femoral veins. 5. Valvuloplasty in the superficial femoral and profunda femoris veins. 6. Division of poorly recanalized superficial femoral vein with axillary vein transfer to profunda femoris vein. (From Raju S, Fountain T, Neglén P, Devidas M. Axial transformation of the profunda femoris vein. J Vasc Surg 1998;27:651–659, Mosby-Year Book, Inc., with permission.)

upon anatomic variations in the axilla and the repair requirements in the groin are shown in Figure 9. When two sequential valves are present in the axillary vein, they can be inserted separately into the superficial femoral and profunda femoris veins. Alternatively, the profunda femoris can be plugged end-to-side between the valves with the two-valved segment inserted into the femoral vein, which is somewhat easier than separate insertions. If only one of the two femoral veins requires reconstruction with the axillary valve technique, the entire two-valved segment is best inserted into the chosen vein to function as sequential valves. The second valve may function as a backup if the first valve should fail for unknown reasons, as happens in 20% in the first year. When undertaking multiple valve reconstructions involving the superficial and deep femoral veins, it is not uncommon to mix and match techniques according to prevailing circumstances. Axillary valve transfer may be required for one venous segment, and the other can be repaired by a direct valve technique (e.g., transcommissural repair). In cases of axial transformation of the profunda femoris vein, the superficial femoral vein may be small and poorly recanalized. If so, it may be divided rather than undertaking a formal valve reconstruction because much of the outflow goes through the enlarged profunda femoris vein. When there is complete axial transformation, the profunda femoris is the target of repair,[11] and the superficial femoral vein is occluded. When axillary vein transfer is performed in this setting, it can be inserted with at least the upper suture line in the common femoral vein, as profunda femoris is the only inflow into this segment. This technical variation is feasible only if proper size match is present, but it is simpler than direct insertion into the profunda femoris vein; dissection and exposure of which can be difficult in these instances.

Axillary vein valves can be inserted into trabeculated veins with excellent long-term patency and valve function.[15] Technical variations adapted for anastomosis in trabeculated veins are shown in Figure 10.

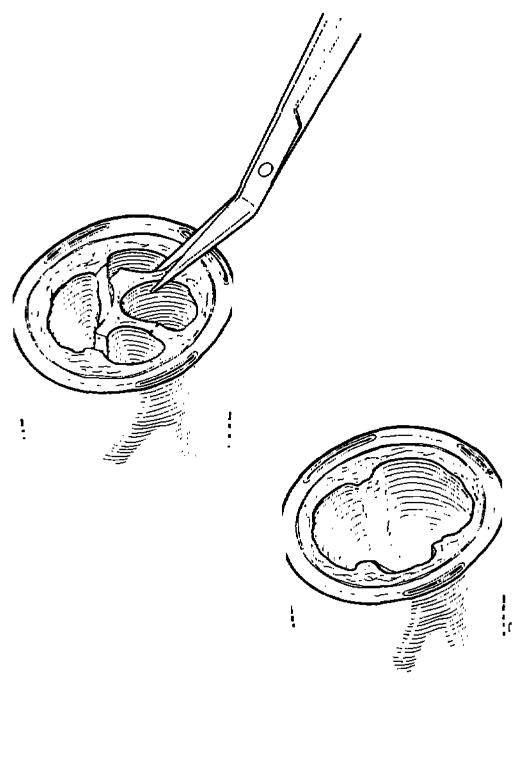

Fig. 10 Axillary vein transfer in trabeculated veins. The intraluminal synechiae are excised at the anastomotic site to create a single lumen in preparation for axillary vein transfer. The thin-walled vasa vasorum collaterals are best incorporated in the suture line. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg; 1999; 29:1050–1064, Mosby-Year Book, Inc., with permission.)

PERIOPERATIVE AND POSTOPERATIVE CARE AND ANTICOAGULATION

Patients with hypercoagulable syndromes are started on dalteparin sodium preoperatively. All patients receive intravenous heparin (5000 to 10,000 units) during surgery. Heparin is not reversed. Dalteparin sodium (5000 units daily) is started in the recovery room and administered subcutaneously for 7 to 10 days. Warfarin sodium is started on the first postoperative day and adjusted to a target INR of 2.5 to 3.0 for 6 weeks and 2.0 to 2.5 thereafter. This level is maintained indefinitely in patients with hypercoagulable syndromes. In others, warfarin is reduced to a "low-dose" regimen[16] of 1 to 2 mg a day at 4 months and continued indefinitely at this dosage. The low-dose regimen is known to be prophylactic against venous thrombosis[16] even though protime is seldom prolonged. Routine protime determinations are not necessary with this regimen.

Pneumatic compression is routinely used in the postoperative period. Ambulation is begun on the first postoperative day with instruction on calf exercises by a therapist. Patients are fitted with a semirigid leg support (Circaid™) to control postoperative edema. Patients are generally discharged on the fourth postoperative day with training for self-administered dalteparin sodium to be continued until target INR is reached. Arrangements are made with the local physician to monitor and control warfarin administration. Patients are encouraged to be active physically and engage in exercise regimens of their choice, including walking. They are released to resume work 3 to 4 weeks after surgery with no restrictions except for lifting heavy weights (>25 lb) or maneuvers likely to produce heavy Valsalva effort for up to 2 months after surgery. Patients are instructed to wear a leg support at all times except in bed during the first month, after which they are encouraged to find their own level of usage of the device. Most patients abandon the device altogether[4,15] or use it intermittently at times when they stand for prolonged periods. Some prefer to switch to a more elastic type of support for regular or intermittent use after the first month.

COMPLICATIONS

Wound seroma and hematoma occurred in 6% of patients. Superficial wound infection occurred in 6%, and deep wound infection occurred in 2%. Loss of prosthetic sleeve from infection occurred in only 2%. These infection data are remarkable because nearly one third of patients had open stasis ulcers at the time of surgery. Incidence of postoperative (<6 weeks) DVT was 4%, a low figure considering the postthrombotic etiology of many of the operated patients. This DVT incidence is comparable with the incidence in arterial vascular surgery. Most of the cases of DVT occurred in the distal venous tree or in the opposite limb. Only one axillary vein graft was lost from this cause. Postthrombotic patients as a group do suffer from recurrent venous thrombosis unrelated to surgery. The cumulative incidence was 6% in the operated patients over the duration of follow-up. The cumulative incidence of cellulitis/lymphangitis was 5%.

FOLLOW-UP PROTOCOL

Patients are seen in follow-up at 6 weeks, and at 4 months, and at longer intervals thereafter. Duplex examination, airplethysmography, arm/foot venous pressure differential, and ambulatory venous pressure measurements of the operated limb are repeated at 3 to 4 months after surgery and at 1- to 2-year intervals thereafter. Some deterioration in valve closure times of the transferred valve (up to 2 seconds) is not unusual, but at this level the transferred valve appears to retain useful function with little clinical deterioration.[9,15] Venous filling time (VFT) on ambulatory venous pressure measurement and venous filling index (VFI) are particularly useful in monitoring global reflux. Substantial improvement in these parameters with surgery carries a good prognosis for sustained clinical remission. Conversely, failure to achieve prolongation of VFT indicates a poor prognosis. Postoperative VFT of less than 5 seconds is associated with higher clinical recurrence.[15]

Our experience indicates that saphenous reflux contributes significantly to VFT. A deterioration in VFT that had remained stable may indicate new onset of saphenous reflux not previously present. Recurrent DVT may also result in VFT deterioration, often with deterioration in arm/foot differential as well. A third cause is failure of the transferred valve itself, most of which such failures occur in the first 3 postoperative years. This is also an indication for restudy. Valve loss after the third year is relatively rare. Failure from dilatation of the axillary vein graft, once a common occurrence when the valves were not wrapped in a prosthetic sleeve, no longer occurs. Late failure with the current technique appears to result from either stenosis of the axillary vein graft or an unknown cause. The precise cause has been identified in few of the failed grafts. Regardless of the cause of failure, an aggressive approach with repeat axillary valve transfer can restore the patient to clinical remission. Redo axillary vein transfers are carried out at a fresh site, such as the midfemoral or popliteal, after the femoral reconstruction has failed. The cicatrix from previous surgery usually precludes reoperation at the original site.

CLINICAL RESULTS

Transferred axillary vein grafts enjoy a high rate of patency even in postthrombotic trabeculated veins (Fig. 11). Actuarial curves of *complete* and *sustained* healing of the stasis ulcer/dermatitis without breakdown are shown in Figure 12. Similar results are achieved with patients operated for nonulcer indications such as pain, painful edema, recurrent cellulitis, or recurrent calf vein thrombosis. The results appear to be durable, extending up to 5 years or longer.[59] These results are not different from those achieved with direct valve

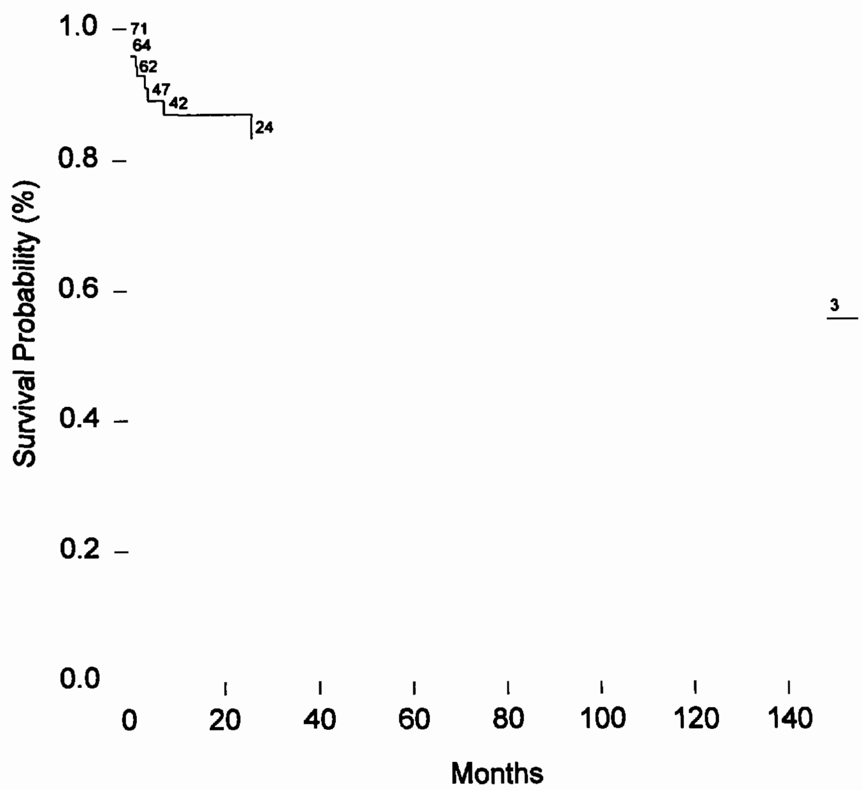

Fig. 11 Cumulative patency rate of axillary vein transfers in a cohort of 102 transfers to trabeculated postthrombotic veins. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29: 1050–1064, Mosby-Year Book, Inc., with permission.)

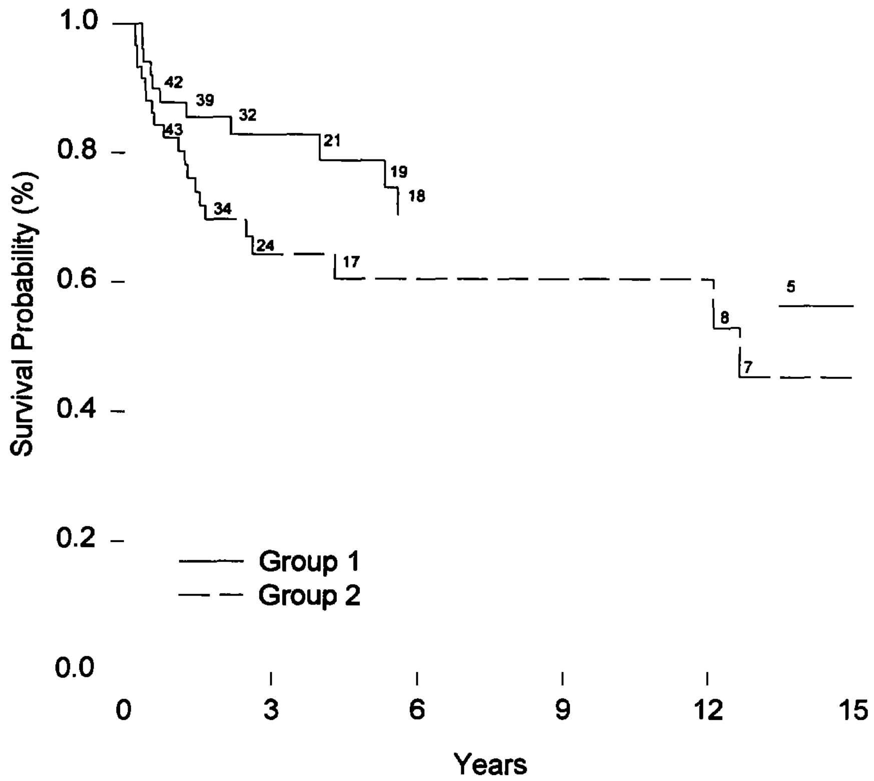

Fig. 12 Actuarial curves of ulcer healing after axillary vein transfer to non-trabeculated (group 1, n = 51) and trabeculated (group 2, n = 59) recipient venous segments. Limbs at risk at selected time intervals are shown above each curve. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated postthrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

repair techniques such as internal valvuloplasty[4,7,9,15] (Fig. 13). Furthermore, the results are similar in primary and postthrombotic patients,[9] including those with "axial transformation" of the profunda femoris vein.[11] When axillary vein transfer is successful in relieving symptoms, patients discard their compression support.[4] Based on these results, an aggressive approach to valve reconstruction in postthrombotic cases appears justified.

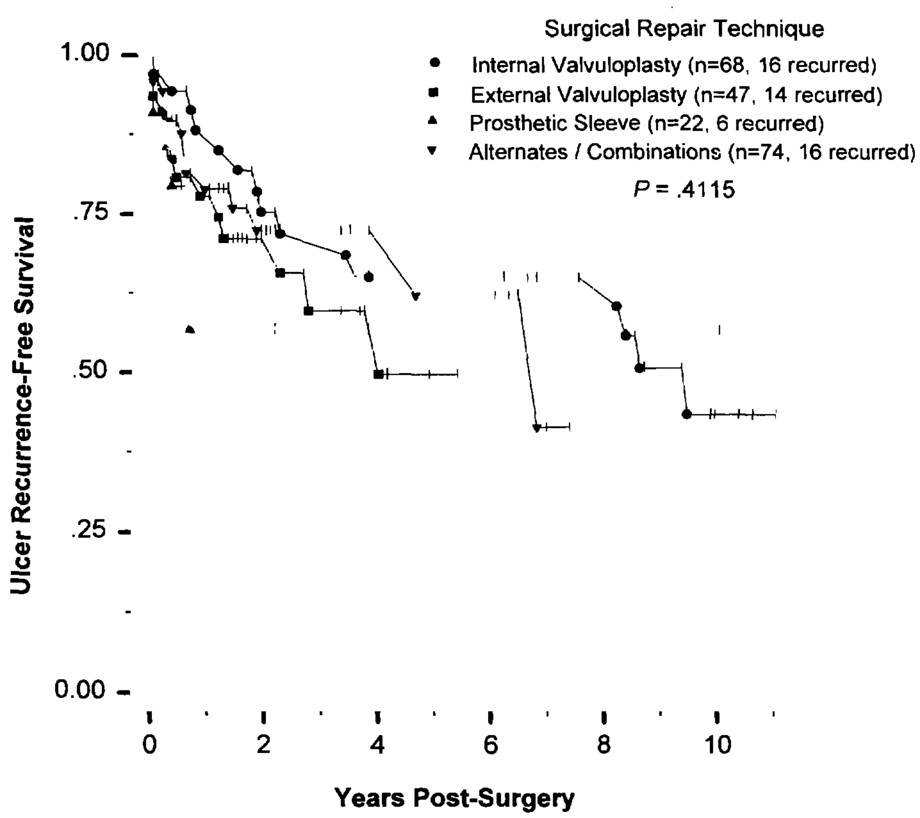

Fig. 13 Estimation of ulcer-free survival based on surgical technique used in valve reconstruction. No difference was seen between different reconstruction techniques; ulcer recurrence-free survival curves were similar. Fifty-four axillary vein transfers are included in group alternates/combinations; as a separate group, 54 axillary vein transfers had ulcer recurrence similar to other techniques. (From Raju S, Fredericks RK, Neglén P, Bass JD. Durability of venous valve reconstruction techniques for "primary" and postthrombotic reflux. J Vasc Surg 1996;23:357–367, Mosby-Year Book, Inc., with permission.)

Valvular Competence

Nineteen percent of axillary valves become incompetent during the first few months after surgery. The precise cause is unknown. Further deterioration in duplex competence is more gradual[15] (Fig. 14). Interestingly, late loss of function does not invariably lead to clinical recurrence. A number of explanations have been offered for this. There appears to be an approximately 20% difference between actuarial curves for ulcer recurrence and duplex incompetence.[15] The situation is reminiscent of the noted difference between graft patency and limb survival in arterial bypass surgery.

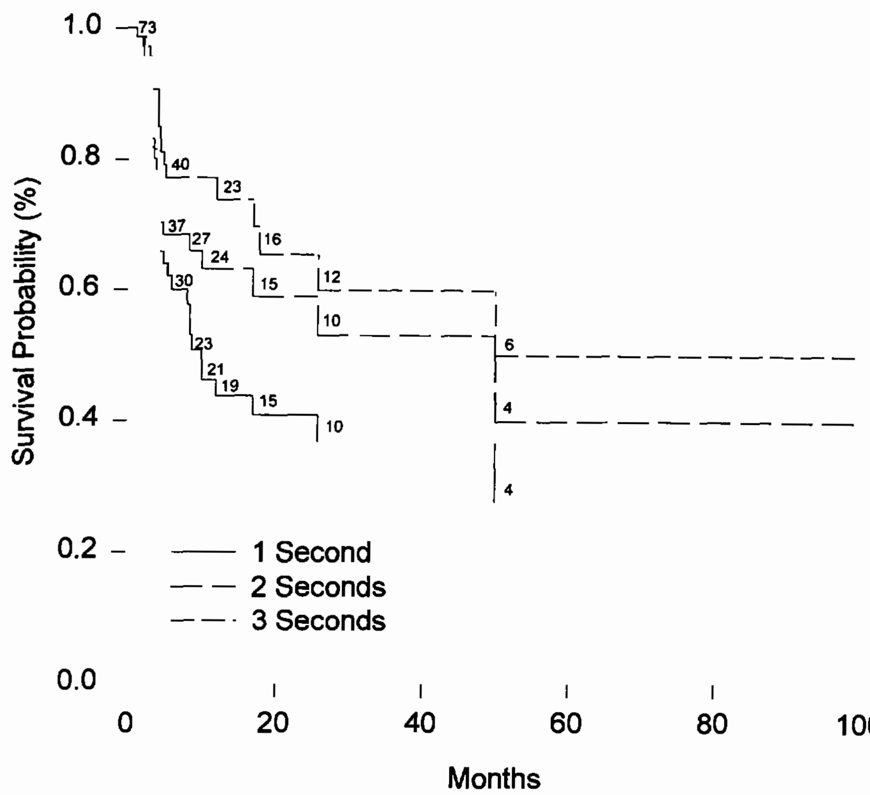

Fig. 14 Valve closure times of transferred axillary valves; survival probability (actuarial) for valve closure times of 1 second or less, 2 seconds or less, and 3 seconds or less are shown. Number of valves at risk at selected intervals are shown above each curve. (From Raju S, Neglén P, Doolittle J, et al. Axillary vein transfer in trabeculated post-thrombotic veins. J Vasc Surg 1999;29:1050–1064, Mosby-Year Book, Inc., with permission.)

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Expert Commentary

Vikrom S. Sottiurai, M.D.

It is generally agreed among the venous valve reconstructionists that axillobrachial valve transfer is the final option when valvuloplasty is not feasible. The latter is often due to postphlebitic valvulopathy manifested as valve cusp perforation or trabecularization of valve and vein wall.

Due to the pressure differential between the upper and lower extremity, coupled with the more delicate anatomic structure of the axillobrachial valve, the durability in valve transfer is not comparable to that of the lower limb internal valvuloplasty (competence of internal valvuloplasty:126/167[75%] vs. valve transfer 18/45[40%], mean follow-up 87 months vs. 79 months, respectively).[1] Furthermore, the high incidence of transferred valve incompetence (24/45, 54%) requiring valvuloplasty has tampered the enthusiasm of valve transfer as a preferred mode of deep valve reconstruction. That transferred valve requiring internal valvuloplasty is more prevalent to maintain valve competence than those without the need of valvuloplasty in long-term follow-up is a surprising and unexpected observation (competence of transfer valve 5/15 vs. transferred valve + valvuloplasty 9/16, mean follow-up 74 months vs. 72 months, respectively[1-4]). Recognizing the need of transferred valve to adapt to an environment with frequent pressure fluctuation in the lower extremity from supine to erect position, respiration and valsalva in conjunction with the delicate histomorphologic feature being more susceptible to valve apparatus distention, it is not unexpected that functional and morphologic deterioration will occur in the axillobrachial valve. Thus, tightening of the valve cusp apposition with precise valve edge alignment and valve cusps suspension to reduce the hammock configuration using internal valvuloplasty has become more tolerant to the hemodynamic and morphologic demands imposed upon the transferred valve. External valvuloplasty, either with Kistner's technique or transcommissural technique ± angioscopic assistance has its limitations, namely: (1) precise valve cusp apposition and alignment cannot always be attained; (2) valve cusp suspension is not possible; (3) transcommissural external valvuloplasty has the tendency to create a triangular disparity as a result of flattening of the valve leaflets to the vein wall at the commissure and the point of the leaflet apposition at a short distance from the commissure. This deficiency in external valvuloplasty may not be recognized in a visually pleasing qualitative positive stript test with patient in the neutral venous pressure–supine position, without valsalva and reversed Trendelenburg's position + valsalva to augment luminal pressure and diameter.

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Hence, quantitative assessment of the valve competence and other venous hemodynamic parameters known to affect the durability and efficiency of valvuloplasty is mandatory. This can be accomplished by transvenous pressure monitoring via a foot vein with transducer assistance ± valsalva (>50 mmHg) in supine, incline, erect and ambulatory positions. Other factors worthy of attention in order to achieve optimal hemodynamic effects in deep valve reconstructions are: (1) location of valvuloplasty or valve transfer; (2) prevention of extravalvular reflux via collateral veins. Performing valvuloplasty or transferring arm vein valve, cryopreserved valve or biologic valve to the femoro-popliteal vein at the adductor hiatus or popliteal vein not only can achieve optimal hemodynamic advantage (competence of proximal superficial femoral vein 10/15, fem-pop junction 15/15, pop. 8/8 at a mean follow-up of 32, 30, 36 months respectively),[1,3] but also has easy accessibility to interrupt the collateral veins that converge at this anatomic site. Access to the collateral veins in the proximal superficial femoral vein is difficult if not impossible due to the diverging distribution of the superficial and deep femoral veins. Hemodynamic improvement resulting from collateral vein interruption has been well documented preceding the valvuloplasty.[3,5]

In our experience, internal valvuloplasty using the combined transverse and vertical venotomies unequivocally surpassed external valvuloplasty in healing venous ulcer (79% vs. 49%), durability and prevention of reflux causing leg swelling and other associated symptoms.[1-4] Valve transfer is only performed in postphlebitic valve in our practice. The long-term result is surprisingly disappointing when compared with de Novo valvuloplasty of the lower limb (126/167 [76%] vs. 18/45 [40%]).[5] Our recently completed prospective randomized assessment of internal versus external valvuloplasty with long-term follow-up lends credence to the statement that internal valvuloplasty far surpasses external valvuloplasty in all parameters employed in the comparative analysis.

External wrapping to contain vein dilation is an attractive modality that has not fulfilled its theoretic capability in our experience, particularly when perfomed in a neutral pressure supine position; reversed Trendelenburg's position plus valsalva increases the vein circumference by 24 ± 6%. Thus, wrapping the transferred valve in supine position with nonexpansive material such as PTFE should be executed with extreme caution lest stricture will ensue. Fibrotic strictures were observed both in human and canine studies with external PTFE and autogenous wrappings.

In conclusion, our prospective comparative studies, cumulative data and long-term follow-up form the basis of our decision that: (1) internal valvuloplasty using the combined transverse and vertical venotomies in a supravalvular approach is preferred over external valvuloplasty; (2) valvuloplasty or valve transfer in the popliteal or the juxtapopliteal portion of superficial femoral vein offers the optimal hemodynamic advantage in single valve correction;

(3) collateral femoral veins should be interrupted to avert extravalvular reflux; (4) quantitative assessment of the hemodynamic status is mandatory to accurately interrogate the effects of deep valve correction and collateral veins elimination; (5) there is a high incidence of transfer valve incompetence in situ (24/45–54%)[5]; and recurrent ulcer (23/45–51%) in long-term follow-up.[3]

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The Last Word

Seshadri Raju, M.D.

Dr. Sottiurai in his commentary summarizes his results with a variety of valve reconstruction techniques, both direct repairs and axillary valve transfers. His critical insights and technical innovations gained from long experience with valve reconstruction surgery add to the growing body of literature on the topic. We concur with his recommendation that axillary valve transfer be considered in a given patient only when direct valvuloplasty is not feasible. We also agree with him that functional outcome of internal valvuloplasty, as measured by serial duplex competence, is superior to other described techniques of valve reconstruction.[1] Nevertheless, *clinical* results with a variety of other valve reconstruction techniques are substantially similar to those achieved with internal valvuloplasty, at least up to five years follow-up.[1] This justifies the use of alternative techniques in circumstances where speed of execution is a factor to be considered.

Transcommissural repair of leaky axillary valves adds only 10 to 15 minutes to the procedure, whereas internal repair may easily double the time it takes to perform the axillary vein transfer.

It is noted that Dr. Sottiurai does not wrap transferred axillary valve segments. His somewhat disappointing results with this technique are similar to our own early series[2] where a supporting sleeve to avoid dilatation of the transferred axillary valve segment in its new position was not provided. Since that time, routine use of a supporting sleeve appears to have erased the difference in clinical results noted earlier between axillary vein transfer and other direct valve repair techniques.[1] However, we do share his concern that supporting sleeves fashioned out of reactive materials such as polytetrafluoroethylene may lead to fibrosis and malfunction of the transferred axillary valve. Experimental studies reported by Lane and colleagues[3] clearly document this process. Fibroblastic invasion is certainly one possible explanation to be considered for the early failure of about 20% of axillary valve transfers noted in our experience. Following the suggestion of Gloviczki (personal communication), we have recently started wrapping transferred axillary valve segments with reinforced silicone, with the hope of reducing the incidence of early failure.

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