Pantaloons femoral vein graft as “neoaorta” in infected aortic disease

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Infected abdominal aortic disease and graft infections pose a significant challenge for the vascular surgeon. Thorough radical débridement, either preceded by extra-anatomic bypass or followed by in situ aortic replacement, is the mainstay of treatment. The role of endovascular repair by stent grafts is being increasingly described but is limited to relatively less virulent mycotic aneurysms or as a “bridging” option in sick patients with florid sepsis that necessitates eventual delayed definitive surgical management. Autologous femoral vein has been an excellent conduit for aortic bifurcation reconstruction in this setting. Although various configurations of femoral vein conduit have been described for aortobi-iliac reconstruction, an in-depth knowledge of the venous anatomy, physiology, mechanisms of “profundization,” and techniques of harvest and graft preparation is essential for efficient conduct of the operation and its optimal outcomes. We review in detail these aspects of “pantaloon” femoral vein graft creation as a “neoaorta”.

Use of a large-diameter vascular conduit in the presence of infection has remained a largely unresolved problem. There are reports of treatment of primary aortic infections with antibiotic-impregnated prosthetic grafts and even with endografts, although gross macroscopic infection, rapid aneurysmal growth with systemic sepsis, and positive blood cultures limit their use as the risk of future graft infection is significant (4%-22%), especially with cryografts. In these conditions, femoral vein grafts may be an attractive and viable option with good success rates. Autologous femoral vein is resistant to infection and provides a good conduit for high-pressure aortic replacement. Extra-anatomic bypasses with synthetic grafts have been performed as an alternative approach, but in the presence of septicemia, these are also susceptible to hematogenous seeding. Femoral vein conduit for the construction of a neoaorta is performed mainly for hemodynamically stable patients with either primary or secondary aortic infective disease. Femoral veins as vascular conduit could also be used in the setting of infected previous aortoaoartic or aortobifemoral graft for occlusive or aneurysmal disease. Focal groin infection of aortic graft could be managed by conservative means like débridement, focal excision of the graft, aortic reconstruction by femoral vein, and omentoplasty.

A variety of surgical techniques have been successfully described, but because of lack of robust data, it is difficult to comment on long-term superiority of one technique over other (Fig 1). One of the major determinants between choice of techniques is total length of conduit required, which may vary with different infective causes (ie, aortobi-iliac graft infection, mycotic aortic aneurysm). The Supplementary Video is available online at http://www.jvascsurg.org, and references to time elapsed are annotated in relation to the critical steps and technical insights for the successful conduct of this procedure. Corresponding timings of steps in the Supplementary Video are mentioned in the text in minutes:seconds format (00:00). Our hospital’s Institutional Review Board approved this Supplementary Video recording, and an informed consent was given by patients to photograph and video record the procedure and its subsequent use in any form of academic publication.

OPERATIVE PLANNING

Preoperative duplex assessment. We perform a mandatory preoperative duplex assessment to obtain information on total available length, valve orientation, intraluminal filling defects of femoral vein, and status of profunda.
Fig 1. Multiple possible combinations of the neoaortoiliac system for infrarenal aortic reconstruction. **a,** Aortounifemoral bypass (femoral vein) with crossover femoral-femoral bypass (great saphenous vein [GSV]): favorable in conditions with one side cicatrizied femoral vein. **b,** Aortobifemoral vein bypass: useful in conditions with one side shorter length vein available. **c,** Segmental resection of prosthetic graft and reconstruction with femoral vein: useful in localized infection involving one limb only. **d,** Pantaloons configuration of neoaortoiliac segment.
vein and popliteal veins and to rule out any previous deep venous thrombosis (DVT). In general, >8 mm femoral vein diameter is preferred as an aortic conduit; however, with the “pantaloon” technique, an even smaller femoral vein (≈6 mm or more) could be used.\(^5\)\(^1\)\(^0\)

During computed axial tomography workup of the aortic pathologic process, one may request a study of the deep veins of the thigh in the venous phase, which can give further information of the deep venous anatomy that might be missed by duplex scan.

Fig 2. Steps of pantaloon femoral vein graft neoaorta. a, Femoral vein is harvested and divided flush at its confluence with profunda vein (flush ligated stump is held with forceps). b, Bilateral harvested femoral veins are kept in reverse direction and spatulated at one end. c, Spatulated ends are sutured in inverted V fashion to create bifurcated vein graft. d, Vein graft is implanted in aortoiliac segment after thorough débridement of mycotic abdominal aortic aneurysm.
SURGICAL TECHNIQUE

Incision

Under general anesthesia, we use a two-team surgical approach; the first team explores the aortic disease, and the second one harvests the femoral vein to reduce surgical and anesthesia time. Authors routinely use an intraoperative mechanical DVT pump to prevent postoperative DVT and compartment syndrome. A vertical incision from the inguinal crease just medial to midpoint of the inguinal ligament is extended to the adductor hiatus level (00:06-00:10). Although the described incision in the literature courses on the lateral border of the sartorius, in our practice, after dissecting the common femoral vein, we extend the incision inferiorly by following the femoral vein in the thigh. The incision initially courses medial to the sartorius in the femoral triangle and stays subsartorial for its course until the adductor canal. Its course in the adductor canal can be approached from the lateral aspect of the sartorius. Care is taken to avoid any inadvertent injury to the medial sartorial blood supply in its upper third as well as to the superficial femoral artery (00:10-00:12 and 00:24-00:28) during caudal dissection, noting the relationship of femoral vein to femoral artery.

Ligation of venous tributaries. Multiple veins drain into the femoral vein in the groin and thigh and should be divided between transfixation ligatures with prolene type 12/0 sutures (00:30-00:50). These branches have a larger diameter and thinner walls than their arterial counterparts, and simple ligatures could slip and lead to hematoma or bleeding when they are placed in a high-pressure arterial system. Smaller branches are divided between Ligaclips (Ethicon, Somerville, NJ), which decreases vein harvesting time significantly.

Extent of vein harvest. The proximal extent of dissection is at the confluence of the femoral and profunda veins (00:12-00:16; Fig 2, a). Preservation of the profunda vein provides for venous drainage of the lower extremity and ensures adequate decompression of the popliteal vein through thigh collaterals. If aortic bifurcation reconstruction is limited to the aortoiliac segment (eg, in mycotic aortic aneurysm), femoral vein harvest from both thighs should be sufficient, and dissection should be limited cephalad to the adductor hiatus. In conditions in which the overall required conduit length is longer, vein harvest should not be extended to the popliteal vein at knee level as this may hamper leg venous drainage through the profunda vein and subsequently result in compartment syndrome, requiring fasciotomy. Bilateral femoral veins with additional use of spliced great saphenous vein should be considered to provide longer length conduits.

After a sufficient length of femoral vein is harvested, ligation is performed proximally and distally with transfixion Prolene 3-0 or 4-0 sutures (00:52-01:05). Care is taken to achieve flush ligation at the profunda-common femoral vein confluence so as not to leave a cul-de-sac that could serve as a nidus for DVT and pulmonary embolism.
Primary patency 65% (32 months) 92% at 5 years 97% at 5 years 75%-91% at 5 years
Reinfection rate 3% 4%-22% Complications: 24% 0%-5%

Creating pantaloon graft

The pantaloon graft is prepared on the bench top (Fig 2, b). By gentle inflation with heparinized saline from a 20-mL syringe and engagement with a Tibbs cannula, uniform dilation is achieved, the direction of valves is identified, and any point of leak is repaired with Prolene 6-0 or 7-0 (01:12-01:22 and 02:40-02:46; Fig 2, c). Other described techniques of utilization of femoral vein grafts (Fig 1) need valve excision by eversion,6,7,14 in contrast to the pantaloon graft, which is prepared with reverse vein graft, and valve excision is not required. Veins are spatulated on one end up to 3 cm (01:23-01:40) and sutured together in a V fashion with running 5-0 Prolene suture starting from the apex of the posterior vein valves going down to the crotch of the graft and returning to the anterior apex (01:56-02:38). This ensures that precise sutures can be taken around the crotch of the graft to prevent narrowing at that level. Because the aortic end of the graft is made by longitudinally suturing veins at their popliteal end, even two veins of 7 mm in diameter each will eventually make a Y graft of 14 mm in diameter at the aortic end; therefore, aorta to graft size mismatch is not an issue.

After preparation of the pantaloon graft, it is implanted in the aortoiliac segment in a standard fashion after excision and débridement of native disease (mycotic aneurysm in this case; 02:48-04:32; Fig 2, a). We use local instillation of 3 g (10 capsules of 300 mg each) of rifampicin after débridement of infected aortic tissue, based on institutional practice and good results; however, there has been no clear evidence to prove its efficacy to prevent graft infection (04:34-04:44).

Wound closure and postoperative care

Groin wounds are closed in layers with suction drains. We prefer to keep patients on full anticoagulation for 2 weeks. An external DVT pump is used in the immediate postoperative period, followed by class II compression stockings thereafter. If vein harvest includes the great saphenous vein as well or extends beyond the adductor canal, the limb is closely observed for compartment syndrome, and if it is required, fasciotomy is performed.

Vacuum-assisted closure therapy is a useful tool for wound complications, especially lymphatic oozing from the incision wound as well as for care of fasciotomy wounds. Follow-up computed tomography or magnetic resonance angiography should be done to look for any possible kink, stenosis, or aneurysmal dilation of the graft (Fig 3).

DISCUSSION

Infected aortic aneurysms are extremely rare and represent only a fraction (0.7%) of all aortic aneurysms.15 Aortic infections secondary to a previous procedure are relatively common (0.5%-2% of aortic surgeries). However, either primary or secondary infective aortic disease has been one of the most difficult and highly morbid conditions to treat (mortality, 10%-36%; limb amputation rate, 10%-45%; new graft infection, 10%-15%).1,3

Hemodynamic stability of the patient, degree of contamination and scarring in the retroperitoneum, proximity of visceral vessels, and quality (post-thrombotic changes, length, and diameter) of the femoropopliteal venous conduit are major determining factors for choosing an optimum treatment modality.

Deep veins of the lower extremity are a widely accepted conduit of choice for in situ reconstruction in patients with infective diseases and stable hemodynamics. Schulman and Badhey14 first described use of a femoropopliteal vein segment as a vascular conduit. Clagett et al6-7 have previously described creation of an aortic bifurcation by use of femoral vein as a "neoaortoiliac system." Femoral vein conduit has also been shown to be more resistant to infection despite being in a bacterial bath.11 Although some degree of dilation of venous segments has been seen over time, aneurysmal enlargement is rarely reported.11 There is a concern among surgeons that an acute rise in venous pressures in the leg after femoropopliteal vein harvest may result in compartment syndrome, requiring fasciotomy in up to one fifth of patients.13 Profunda vein-popliteal channels are present embryologically and open subsequent to femoral vein occlusion.15 The key to reduce the need for fasciotomy is to limit femoral vein harvest to the adductor canal, to preserve the profunda vein and popliteal genicular draining veins, and routinely to use intraoperative DVT pumps.12,13 In conditions in which the overall required conduit length is longer, vein harvest could be extended to the popliteal vein at knee level. However, close monitoring of the leg for compartment syndrome and, if required, early fasciotomy should be performed as this may hamper leg venous drainage and potentially lead to compartment syndrome. Although there are no clear-cut guidelines for performing fasciotomy, authors maintain a low threshold for performing fasciotomy when compartment syndrome is suspected.
Because prolonged operative time is a concern, a few surgeons prefer staging the vein harvest on the day before aortic grafting. However, we prefer a two-team approach to reduce operative time. One team explores the abdominal aorta to reduce operative time. The other team harvests and prepares the femoral vein graft. With this strategy, this operation rarely exceeds 3 to 4 hours in duration.

In the long term, approximately 35% of patients develop limb edema, which usually responds to compression therapy. Chronic venous insufficiency (lipodermatosclerosis and venous ulceration) is rare. Broad-spectrum antibiotics are started preoperatively and guided by blood culture when possible. Postoperatively, long-term oral antibiotics are continued according to antibiotic sensitivity from culture of aortic tissue and graft samples. The length of the antibiotic regimen is tailored to the patient’s clinical status.

Long-term follow-up involves surveillance for graft patency as well as for any possible graft infection. Because there is no guideline for surveillance, we follow institutional protocol, which includes clinical evaluation and venous duplex ultrasound of both lower limbs at 3, 6, 9, and 12 months and then annually thereafter.

A contrast-enhanced computed tomography scan of the abdomen and pelvis is repeated at 6 and 12 months. Any clinical suspicion of graft infection by either persistent low-grade fever or elevated white blood cell count is interrogated by positron emission tomography scan.

Although the pantaloon technique restores the aortic bifurcation to its normal anatomic configuration, it has some inherent limitations. Because the pantaloon graft has a limited length despite the longest vein harvested, it is difficult to use in conditions like an infected aortic prosthesis, for which the overall length required is more. In such scenarios, the pantaloon graft could be lengthened further by great saphenous vein extensions, using alternative conduit configurations (Fig 1) or extending vein harvest beyond the adductor hiatus bilaterally. The diameter of a single femoral vein may be small for the aorta and make proximal anastomosis technically demanding with longer operative times. Our suggestion and demonstration of a limited suture line just enough to create the union of the limbs additionally reduces time involved in creating the pantaloon. Using this technique, we have not seen any suture line bleeding in our experience.

The 5-year cumulative primary patency of the aortic bifurcation reconstruction with femoropopliteal veins is 83%, and secondary or assisted patency is nearly 100%. The limb salvage rate is 86%. Aneurysmal dilation of the venous conduit is rare. Different conduit options used for infective aortic disease and their outcomes are described in the Table.

CONCLUSIONS

The femoral vein in pantaloon configuration is an excellent conduit to replace the aortic bifurcation in infective aortic disease. It is resistant to infection and provides excellent long-term patency. Limiting distal dissection to the adductor hiatus and proximally preserving the profunda vein seem to reduce the need of compartment decompression. Unlike other configurations, the pantaloon configuration permits use of smaller diameter femoropopliteal vein and eliminates the need for excision of vein valves.

REFERENCES


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Additional material for this article may be found online at www.jvascsurg.org.