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Aortic reconstruction in infected aortic pathology by femoral vein "neo-aorta"

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ABSTRACT

The use of autologous femoral veins for in situ reconstruction of the aortoiliac segment is an effective technique to treat native aorta or prosthetic graft infections. The indications, technical details, and outcomes of this procedure are detailed. Graft infection involving the aortic segment, while rare, remains one of the most challenging vascular surgery conditions to treat. The original technique of "neo-aortoiliac surgery" with in situ autologous vein grafts has evolved over the past 25 years and remains a worthwhile alternative for the treatment of aortic graft infections, with lower mortality rates compared with other extra-anatomic or in situ surgical options. Acceptance of this surgical option is due to low graft re-infection rates, rare graft disruption, and low long-term aneurysmal degeneration. Excision of the femoral veins is associated with acceptable rates of lower limb edema. The use of an autologous femoral vein graft can be considered the standard of care in selected patients for the management of aortic graft infections. Optimal management of patients with aortic graft infections requires consideration of all potential therapeutic options because no single modality can be used, and individualizing treatment according to the clinical condition will yield the best patient outcomes.

1. Introduction

Aortic and aortic graft infection is a formidable entity to manage at any center across the globe. Fortunately, aortic graft infection rates are low (0.2% to 5%) in the perioperative period and over long-term follow-up [1–3]. The management of these patients is a daunting task that requires control of infection and often revascularization. Infected aortic pathology requires antibiotics, eradication of septic focus by excising the graft with thorough perigraft debridement of infected and devitalized tissue, and reconstruction of the excised aorta or graft. Revascularization is achieved by an extra-anatomic route or in situ reconstruction from homograft [4] or antibiotic-impregnated prosthetic graft [5] or an autologous femoral vein graft reconstruction [6], depending on the patient's condition, vascular disease extent, and virulence of bacteria. Endovascular stent grafting is used mostly as a bridging therapy in bleeding situations in cases of graft infection [7].

The limitations associated with extra-anatomic bypass, allograft use, and antibiotic impregnated graft use with the relatively infection-resistant potential of autologous tissue, led to development of afemoral vein neo-aorta for infected aortic pathologies [6].

Neo-aorta reconstruction with femoral veins allows for in situ placement and, therefore, eliminates the risk of stump blowout. Different reconstructions can be used to match the

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aortic diameter. Autogenous vein graft use reduces the long-term use of antiobiotics significantly. The risk of need for fasciotomy has declined nearly 12%, and lower limb edema requiring compression garments occurs in only 11% to 15% of patients [8]. In addition to the benefits already mentioned, low risk of femoral vein aneurysmal degeneration over the long term has increased its potential for use as neo-aorta in infective aortic pathologies.

We review preoperative planning, dissection, and preparation of the femoral vein and vascular reconstructions commonly used for femoral vein neo-aorta. Finally, global experience will be reviewed, with emphasis on long-term outcomes and morbidity associated with femoral vein harvest.

2. Investigations to diagnose graft infection

2.1. *Clinical features*

In aortic grafts confined to the abdomen cavity, unexplained fever, ileus, or abdominal distention might be the only clinical sign. If infection involves an extracavitary graft (groin), the initial sign of infection may manifest as overlying inflammation/cellulitis, cutaneous draining sinus tract (Fig. 1), or

Fig. 1 – Infection manifesting as overlying inflammation/cellulitis, cutaneous draining sinus tract with graft extrusion.

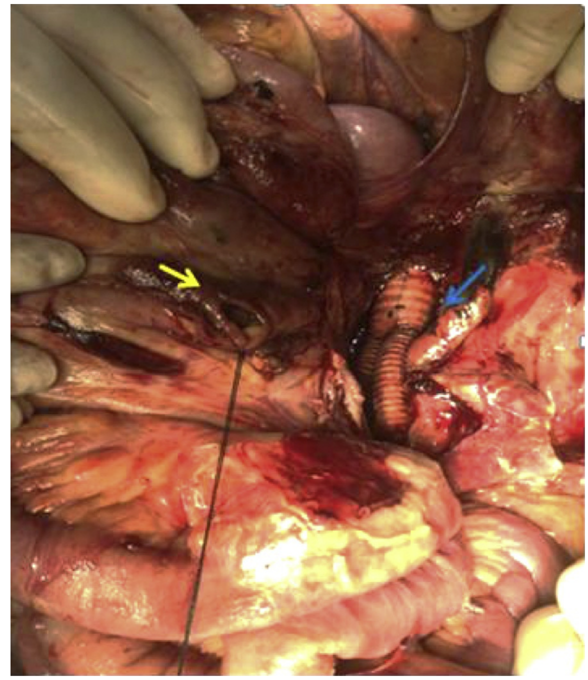

Fig. 2 – Intraoperative picture showing rent in jejunum, which was eroded after coming in direct contact with polyester graft (blue arrow).

anastomotic pseudoaneurysm. Any patient with gastrointestinal bleeding and an aortic graft should be presumed to have graft enteric erosion/fistula (Fig. 2) until another source of bleeding is conclusively identified on endoscopy or no graft–bowel communication is verified at surgery.

In patients with nonspecific symptoms and ultrasound or computed tomography (CT) evidence of perigraft fluid, careful review of the operative notes may provide clues to support the diagnosis of graft infection.

Early graft infections usually occur with *Staphylococcus aureus* or Gram-negative bacteria, which classically manifest within weeks of the procedure as fever, leukocytosis, wound complications, and perigraft purulent discharge. Patients with grafts infected by *Staphylococcus epidermidis* are seen months to years after graft implantation, with complications likes anastomotic aneurysm, perigraft fluid cavity, or graft-cutaneous sinus tract. Systemic signs of sepsis (eg, fever, leukocytosis, and bacteremia) are frequently absent.

The clinician should examine the site or sites of graft implantation carefully for any signs of inflammation. Swelling near the anastomotic site can represent perigraft abscess or anastomotic pseudoaneurysm. Other sources of infection, such as infected wounds on foot, osteomyelitis, and urinary calculi, should be sought because these conditions can predispose to hematogenous seeding and graft colonization with bacteria. An elevated white blood cell count with a left-shift differential count and an elevated erythrocyte sedimentation rate are common, albeit nonspecific, findings in patients with graft infection and fever. Routine laboratory testing should also include urinalysis, blood culture, and cultures of

Fig. 3 – Contrast-enhanced computed tomography scan showing multiple air foci around opacified limbs of graft (case of aortoenteric fistula).

other sites of infection, such as foot wounds and surgical wound drainage. All laboratory investigations might be normal in patients with late-appearing perigraft infections with S. *epidermidis*.

Contrast-enhanced CT/CT angiogram is the front-line imaging tool to diagnose most cases of graft infection, which can show presence of inflammatory changes about the aortic graft and adjacent structures (fat stranding), loss of tissue planes surrounding the graft, and perigraft air (Fig. 3) and/or fluid [9]. The sensitivity and specificity of CT scans for accurately diagnosing aortic graft infections is 95% and 88%, respectively, and rapidly approach 100% for perigraft fluid and/or air [10]. Magnetic resonance imaging provides similar information, apart from better differentiation of fibrosis from perigraft fluid [11,12]. Magnetic resonance imaging can more accurately detect small fluid collections from S. *epidermidis* infections. The finding of perigraft air is a normal finding in the initial 2 months subsequent to graft implantation, but should not be considered diagnostic of graft infection until approximately 4 to 8 weeks have elapsed from the initial surgery [13]. Moreover, fluid is not considered to be a concerning finding until approximately 3 months have elapsed [9]. CT or magnetic resonance angiography of the aorta and bilateral lower extremities is also required to assess the extent of the infection along the graft, location of concomitant occlusive disease, and degree of involvement of contiguous gastrointestinal structures. Upper endoscopy may be required if there is any clinical suspicion of an aortoenteric fistula, which can show a clot covering the ulcer or rarely visible graft in the eroded duodenum to confirm the diagnosis, and to exclude other causes of gastrointestinal bleeding, such as peptic ulcer disease or varices.

2.2. *Preoperative duplex assessment*

We perform mandatory preoperative duplex assessment to obtain information on length of available femoral vein; valve orientation; intraluminal filling defects of femoral vein; and status of profunda and popliteal veins, and to rule out any signs of 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) could be used [14,15]. During computed axial tomography workup of the aortic pathologic process, one can request a study of the deep veins of the thigh in the venous phase, which can provide further information on the deep venous anatomy that might be missed by duplex scan.

2.3. *Anesthetic consideration*

General anesthesia is required in all cases requiring neoaortoiliac system reconstruction, with placement of a central venous line in the internal jugular/subclavian vein and a radial artery pressure monitoring line for optimal maintenance of hemodynamic status intraoperatively. Patients should have urinary bladder catheterization, with a urine flow meter bag attached for monitoring of urine output, as suprarenal or supraceliac cross-clamping of the aorta is often required during explantation and reconstruction of the aorta. Because hypothermia can lead to worsening of coagulopathy status, using ambient warm operating room temperature, warmed infusion fluids, thermal blankets, and washing the contaminated cavity with warm fluids are necessary to maintain core body temperature. Availability of 5 units of fresh frozen plasma and 5 units of packed red blood cells is necessary to tackle coagulopathy and optimize hemoglobin status during the intraoperative period.

3. Surgical technique

3.1. *Approach*

We position the patient in supine position, with lower thighs supported on small rolled sheets/bean bags with slight external rotation at hip joints to have good exposure of groins and full length of thighs for adequate harvesting of femoral veins. We prefer 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, which significantly reduces the risk of hypothermia. An intraoperative mechanical DVT pump is used routinely to prevent postoperative DVT and compartment syndrome. A vertical incision from the inguinal crease just medial to the midpoint of the inguinal ligament is extended to the adductor hiatus level. Although the described incision in the literature courses on the lateral border of the sartorius [6,14,16], 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 sub-sartorial 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 during caudal dissection, noting the relationship of the femoral vein to the femoral artery.

3.2. *Ligation of venous tributaries*

Multiple veins drain into the femoral vein in the groin and thigh and should be divided between transpiration ligatures with polypropylene 6-0 sutures. These tributaries 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 Liga-clips (Ethicon, Somerville, NJ), which decreases vein harvesting time significantly.

3.3. *Extent of vein harvest*

The proximal extent of dissection is at the confluence of the femoral and profunda veins (Fig. 4). 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, femoral vein harvest from both thighs should be sufficient, and dissection should be limited cephalad to the adductor hiatus [16–18]. 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 [18,19]. 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 transfixation Prolene 3-0 or 4-0 sutures. 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 act as a nidus for DVT and pulmonary embolism [19,20].

4. Surgical configuration with femoral vein

A multitude of surgical configurations have been described, but because of the dearth of data, it is difficult to comment on the long-term superiority of one technique over other (Fig. 5) [15,16]. One of the major determinants in choice of techniques is the total length of conduit required, which can vary with extent of graft involvement or the primary pathology of aorta (ie, aortobifemoral graft infection, mycotic aortic aneurysm) [16]. A good-sized femoral vein can be used as an aortounifemoral (end to end anastomosis) with femorofemoral crossover with saphenous vein (Fig. 5A) or, after aortounifemoral bypass with one femoral vein, a short-length femoral vein can be anastomosed end to side to the main body and passed on to the contralateral groin for anastomosis to the femoral artery (Fig. 5B). If graft infection is limited to one limb of the aortobifemoral bypass, it can be excised and replaced with femoral vein (Fig. 5C). Pantaloon configuration can be created when diameter mismatch between the small size of the femoral vein (7 to 8 mm) and aorta (14 to 16 mm) is significant and when aortobiiliac configuration is required (Fig. 5D).

5. Creating pantaloon reconstruction

Here we will describe in detail the technical points fir reconstruction of pantaloon configuration. The pantaloon graft is prepared on the bench top (Fig. 5B). 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 polypropylene suture 6-0 or 7-0 (Fig. 5C). Other described techniques of utilization of femoral vein grafts (Fig. 5) need valve excision by eversion [6,15,20] 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 and sutured together in a V fashion with a running 5-0 polypropylene suture starting from the apex of the posterior vein valves going down to the crotch of the graft and returning to the anterior apex. 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 would be the least mismatched.

6. Procedure details of removal of prosthetic graft and revascularization with femoral veins (overview of procedure)

6.1. *Exposure of femoral artery*

We use the upper end of the same incision that was used for vein harvest for femoral artery exposure. Re-do groin dissections are mostly difficult, but slow, careful, and sharp dissection is key to successful exposure of the common femoral artery, superficial femoral artery, and profunda femoris artery. Although our aim is dissection of the common femoral artery, superficial femoral artery, and profunda femoris artery, it may not be possible to dissect them all if there is dense scarring, although edema around the infected prosthetic graft (shows poor take of graft) makes dissection and separation of prosthetic graft easy from all around in the groin. After controlling femoral arteries proximally and distally (sometimes intraluminal balloon control is required if dense scarring does not permit safe profunda artery control with Fogarty embolectomy catheter), we dissect the graft up to

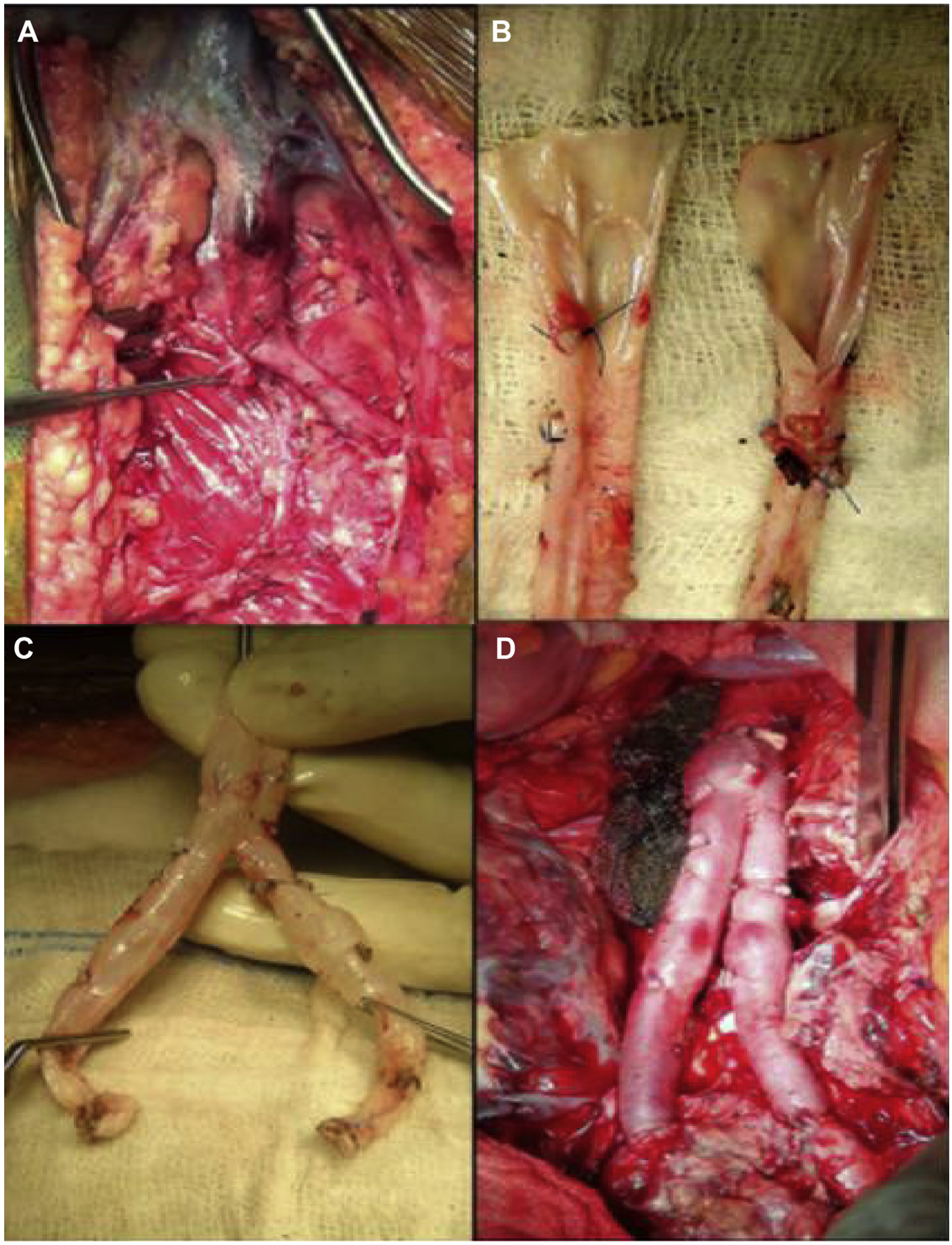

Fig. 4 – Steps of pantaloon femoral vein graft neo-aorta. (A) Femoral vein is harvested and divided flush at its confluence with profunda vein (flush ligated stump is held with forceps). (B) Bilateral harvested femoral veins are kept in reverse direction and spatulated at one end. (C) Spatulated ends are sutured in inverted V fashion to create bifurcated vein graft. (D) Vein graft implanted in aortoiliac segment after thorough debridement of mycotic abdominal aortic aneurysm.

its anastomosis and as far as possible under vision proximally to keep it ready for dismantling after proximal control of the abdominal aorta.

6.2. *Abdominal aorta exposure*

Two approaches can be used, either transabdominal or retroperitoneal, but the preferred one is transabdominal, which allows complete debridement of devitalized necrotic tissue around the graft with thorough lavage with warm saline. Dense scarring around the proximal anastomosis often mandates supraceliac or suprarenal aortic control. Before clamping the aorta, the type of femoral vein configuration required is reconfirmed with preoperative planning (as aortic size and femoral vein size are often confirmed preoperatively with CT and duplex scan). Femoral vein conduit should be ready by now to avoid prolonged aortic clamping and to reduce the ischemia to lower limbs due to clamping. A

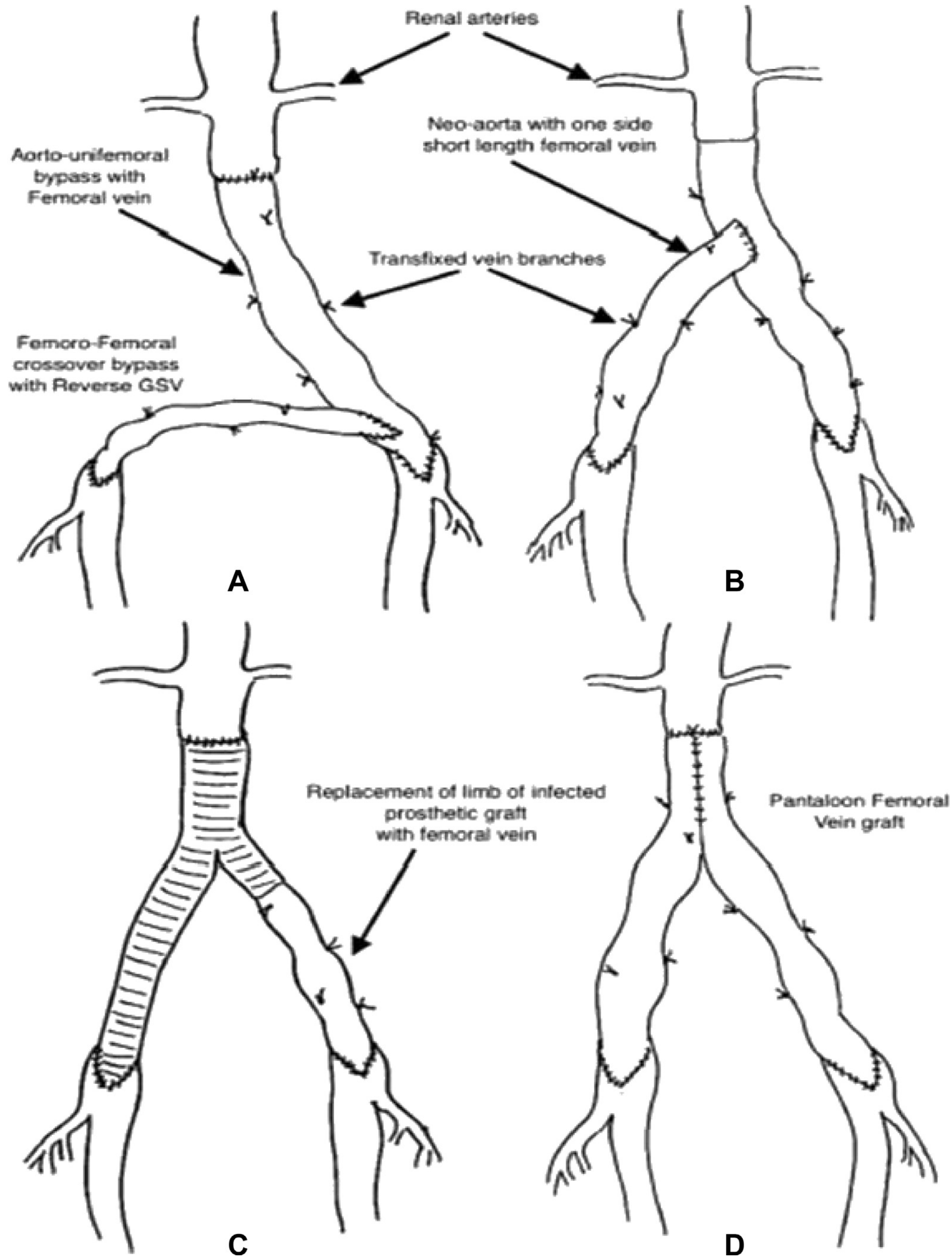

Fig. 5 – Multitude of combinations of the neo-artoiliac system for infrarenal aortic reconstruction. (A) Aortounifemoral bypass (femoral vein) with crossover femoral–femoral bypass (great saphenous vein [GSV]). (B) Aortobifemoral vein bypass: useful in conditions with one side shorter length vein available. (C) Segmental resection of prosthetic graft and reconstruction with femoral vein. (D) Pantaloon configuration as neo-aortoiliac system for aortoiliac segment.

standard 1-mg/kg dose of unfractionated heparin is given before clamping and dismantling of the proximal anastomosis of prosthetic graft with aorta. In the case of endograft, the bare-metal struts are left in situ and the fabric portion is excised and the neo-aortic anastomosis is begun end to end. If proximal anastomosis is end to side, after detaching the graft, the distal end of the aorta can be closed and the proximal aorta can be anastomosed in end to end fashion with the femoral vein conduit. The clamp is shifted to the venous conduit now to curtail the ischemic sequelae of suprarenal/supraceliac clamping. Prosthetic graft dissection is often easy due to the infection process in and around the prosthetic graft unless some portion of the graft is spared and well taken up by tissue, careful dissection should be done in previous tunnels

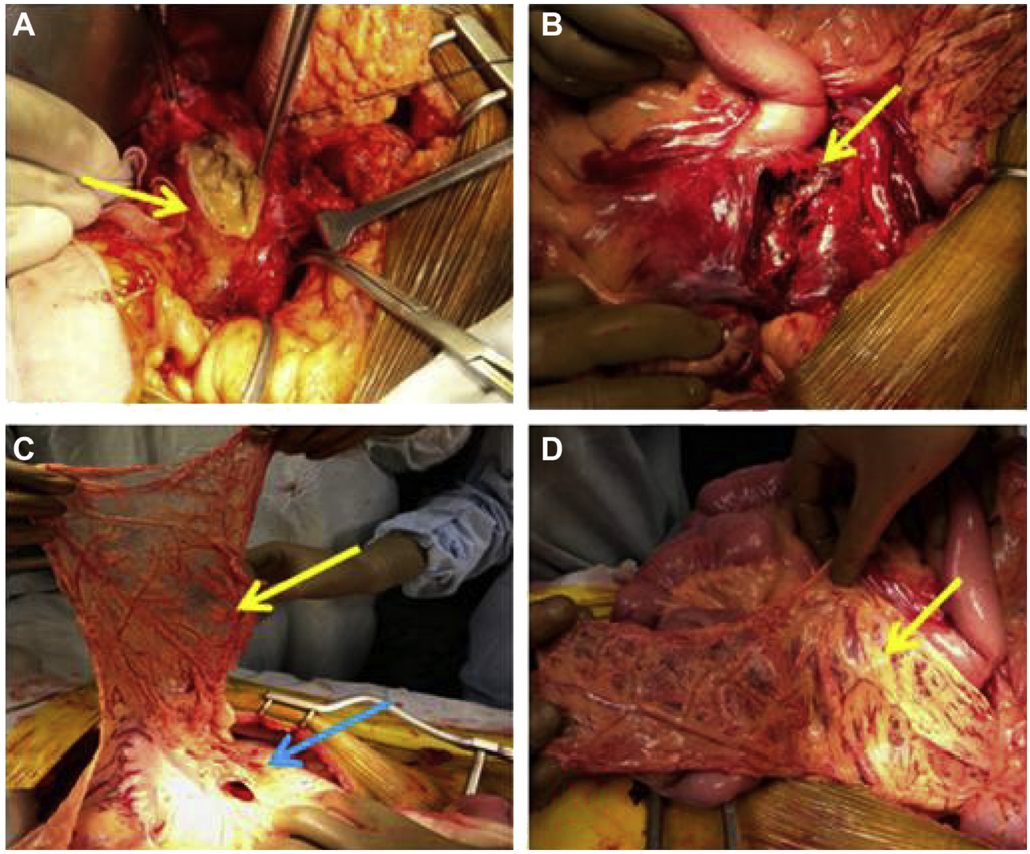

Fig. 6 – Intraoperative picture of repair of mycotic infrarenal abdominal aortic aneurysm. (A) Picture showing purulent material seen after opening aneurysm sac. (B) Inadequate macerated tissue left after thorough debridement to cover interposition graft made with femoral veins. (C) Omental flap constructed from left half of omentum after full mobilization of omentum from mesocolon to have good length (yellow arrow) and window created (blue arrow) on left side of middle colic artery to pass omental flap in infracolic compartment to cover graft and infected area. (D) Area of graft fully covered by omental flap.

of bifurcated limbs of the graft to avoid any iatrogenic injury to the iliac veins and ureters bilaterally. Preoperative placement of double J stents in ureters is helpful for easy identification of ureters to prevent any injury. Femoral vein conduits can be placed in the same tunnels after explanting the prosthetic graft or, rarely, new new tunnels are required. Femoral venous conduits are anastomosed mostly to the common femoral artery, and occasionally to the superficial femoral artery or profunda femoris artery.

6.3. *Closure of wounds*

Native femoral vein grafts are preferably covered with omental flaps, which we usually prepare with the left half of the omentum based on left gastroepiploic artery arcade. Complete mobilization of omentum from transverse mesocolon provides adequate length for flap coverage of graft. The left half of the omentum is passed through a window created carefully on the left side of the middle colic artery to avoid any injury to the arcade of transverse colon (Fig. 6). The rest of the abdomen is closed in standard fashion. We prefer interrupted closure of the abdominal sheath with nylon/polypropylene number 1 to keep dehiscence of abdominal wound to a minimum. We always close the groin wound after thorough wash with warm saline and placement of a closed suction drainage system.

6.4. *Postoperative management*

Broad-spectrum antibiotics are given in the postoperative period until we get culture reports with sensitivity patterns. As many patients are poorly nourished due to prolonged febrile illness and reduced appetite (anorexia), we supplement total parenteral nutrition for faster recovery in the week immediately after surgery and stop once the patient begins adequate intake orally. Mechanical DVT pumps are applied routinely to prevent postoperative DVT and compartment syndrome.

6.5. *Outcomes*

Good overall results of neo-aorta reconstruction with femoral veins compared with extra-anatomic bypasses and in situ bypass in patients with prosthetic graft infection support it as the favored treatment modality over other methods, although it is technically demanding [15,21–23].

Morbidity associated with femoral vein harvest has been found to be low, the rate of fasciotomy has declined to a rate of approximately 12% [24]. The independent predictors of fasciotomy reported are lower ankle-brachial index of 0.4 and concurrent ipsilateral greater saphenous vein harvest [25]. The durability of the neo-aortoiliac system reconstruction is unparalleled, with patency rates as described here. Aneurysmal degeneration was a concern but has not been found in the long-term follow-up data of several reports. Daenens et al [26] had no cases of aneurysmal degeneration at a mean follow-up of 41 months. Similar results were reported by Chung et al [15].

7. Conclusions

Femoral vein harvest and neo-aorta reconstruction is an important and, given the circumstances, reasonably safe surgical option in the definitive management of infected aortic pathology. This should be in every vascular surgeon's armamentarium in a tertiary care hospital.

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