Neoaortoiliac system (NAIS) for treatment of infective aortic disease

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Abstract: Background: Aortic graft infection (AGI) historically has been treated with extraanatomical bypass, graft excision, and aortic stump closure, with very high mortality and amputation rates. In-situ reconstruction is alternatives to this strategy. This study demonstrates our experience in 12 patients with aortic graft infection, treated by graft excision and in-situ aortobiofemoral reconstruction using the femoral vein. **Methods:** During 5 years, all patients with AGI or aortic mycotic aneurysm and have an adequate FPVs were prospectively selected for NAIS procedure. **Results:** The mean ASA score was 3 ± 1, mean operative time was 5.3± 2.1 hours. One patient died postoperative due to MI. The mean follow-up was 16 months. No evidence of reinfection in all patients. **Conclusions:** Using FPV in pantaloon configuration for AGI treatment is an excellent conduit which is resistant to infection.

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Key words: Aortic graft infection, Neoaortoiliac system, femoropopliteal vein

1. Introduction:

Aortic graft infection (AGI) historically has been treated with extraanatomical bypass, graft excision, and aortic stump closure, with very high mortality and amputation rates in addition to the high risk of stump blowout. in-situ reconstruction (synthetic or autogenous) in the infected area is alternatives to this strategy, but has received little attention in the past because of its technical complexity and the lack of suitable conduits.[1,2] Despite advances in surgical and anaesthesiological techniques, such procedures still associated with high operative mortality (20-25%) and 10-15% amputation rate.[3,4] This study demonstrates our experience in 12 patients with aortic graft infection, treated by graft excision and in-situ aortobiofemoral reconstruction using the femoral vein.

2. Methods

The study was performed at two tertiary referral centers in the Middle East (King Salman Hospital, and Al Hada Military Hospital, Saudi Arabia). Our institutional review board approved the study protocol, and written informed consent was obtained from all patients.

Study design

From December 2011 to November 2016, All patients with AGI or aortic mycotic aneurysm and have an adequate femoro-popliteal veins (FPVs) were prospectively selected for NAIS procedure.

Exclusion criteria

Exclusion of patients with FPV thrombosis (current or previous), FPV diameter less than 6 mm, patients with varicose veins and patients with failed aortobifemoral bypass with no evidence of infection.

Preoperative assessment. Ankle brachial index (ABI) is obtained for all patients. Duplex ultrasound assessment of FPV for vein diameter, state of profunda and popliteal veins and to exclude deep venous thrombosis (DVT). The presence of hypoechoic rim around the aortic graft by ultrasound is compatible with AGI. Computed tomographic arteriography (CTA) (fig. 1) for assessment of the aortic pathologic process, and 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.

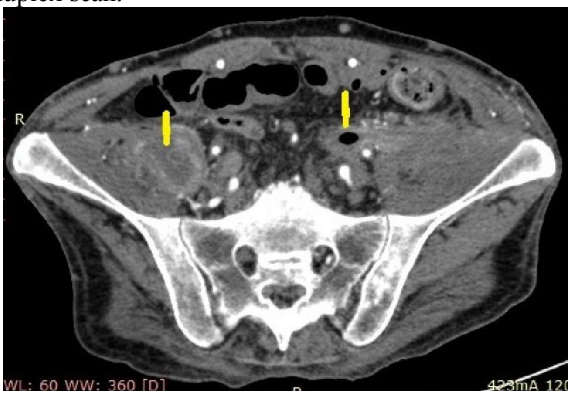

Figure 1: Hypoechoic rim and gas around the iliac limb of infected aortic graft in patient with aortoenteric fistula

Surgical technique

Anesthesia. General anesthesia

Position. Patient is positioned supine, with the legs placed into a "froglegged" position, and supported under each of the thighs.

Operative steps. Using a two team surgical approach; the first team explores the infective aortic disease, and the second one harvests the femoral vein to reduce surgical and anesthesia time. We routinely use an intraoperative mechanical DVT prophylaxis 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, 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 then its course in the adductor canal can be approached from the lateral aspect of the sartorius. Care is taken to avoid injury to the medial sartorial blood supply (by medial reflection of the sartorius muscle to preserve its blood supply) as well as to the superficial femoral artery during caudal dissection.

Ligation of venous tributaries

Multiple veins drain into the femoral vein in the groin and thigh that should be divided between transfixation ligatures with polypropylene 6-0 sutures. 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 (fig2). Preservation of the profunda vein for venous drainage of the lower extremity and ensures adequate decompression of the popliteal vein through thigh collaterals. The distal extent of vein graft is limited to the adductor hiatus.

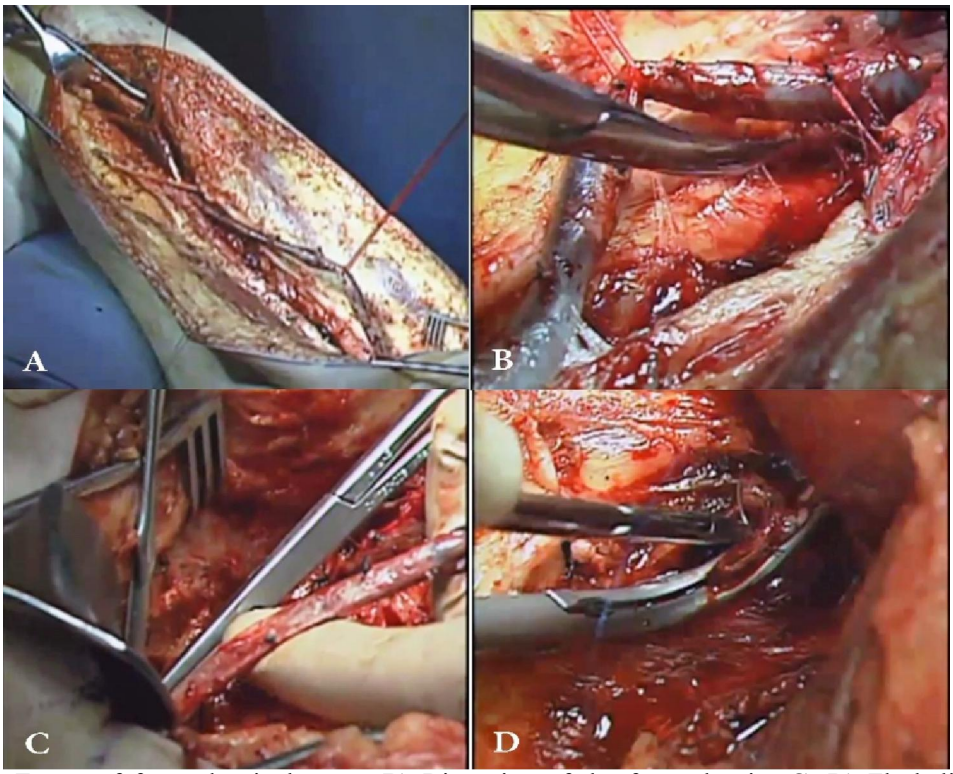

Figure 2: A) Extent of femoral vein harvest. **B)** Dissection of the femoral vein. **C, D)** Flush ligation at the profunda-common femoral vein confluence.

Then ligation is performed proximally and distally with transfixation Prolene 3-0 or 4-0 sutures. 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.

Creating pantaloon graft

Both femoral veins are reversed, so valve excision is not required. Veins are spatulated on one end up to 3 cm and sutured together in V shaped fashion with running 5-0 Prolene. Excision of infected graft, debridement and frequent lavage of the field then the pantaloon graft is implanted in the aortoiliac segment (fig. 3 & 4).

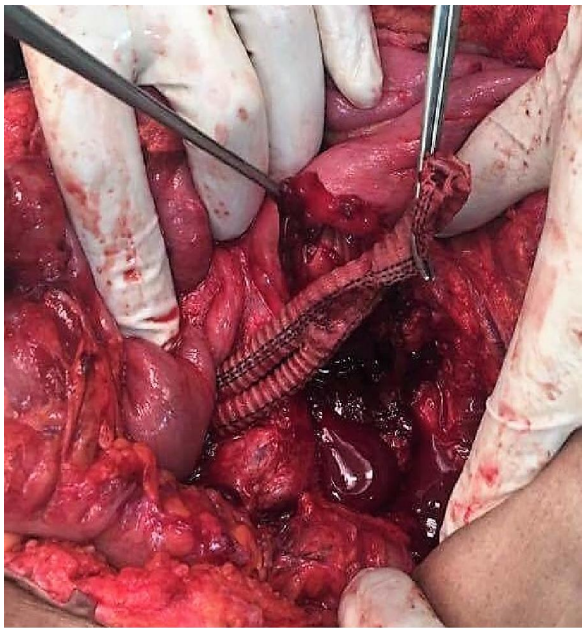

Figure 3: Excision of infected aortic graft.

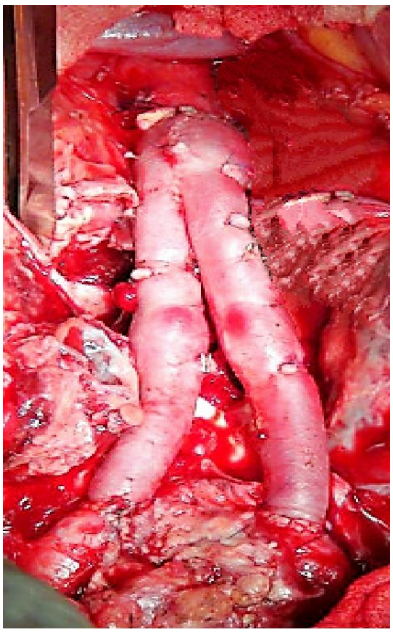

Figure 4: Pantaloon configuration of the aortobifemoral graft.

Wound closure and postoperative care

Wounds closure done in layers with suction drains in the thigh wounds. We keep patients on full anticoagulation for 2 weeks. Intermittent pneumatic compression pump for DVT prophylaxis is used postoperative, followed by class II elastic stockings thereafter. The limb is closely observed for compartment syndrome and fasciotomy is performed if required. Follow-up.

CTA or magnetic resonance angiography (MRA) done 6 months postoperative to exclude kink, stenosis, or aneurysmal dilation of the graft.

Data collection and analysis. Patient demographics, associated comorbidities, clinical presentation, cultures result, (American Society of Anesthesiologists (ASA) class, operative details, fluid, and transfusion used, operative time, additional surgical procedures e.g. infrainguinal bypass), complications, and mortality were recorded for all patients.

Follow-up involves surveillance for graft patency as well as for any possible graft infection. Clinical examination and duplex ultrasound graft surveillance every 4 months during the first year and then every 6 months thereafter. CTA done If indicated. Any clinical suspicion of graft infection by either persistent low grade fever or elevated white blood cell count is to be confirmed by positron emission tomography scan.

Definitions. Primary and secondary patency and limb salvage data were defined according to the reporting standards for the SVS.[5] Graft failure was defined as an occluded graft or significant stenosis requiring intervention. Graft disruption or dehiscence due to nontechnical cause was considered to be due to graft reinfection.

Figure 5: Follow-up CTA of aortobi-iliac graft to exclude any possible kink, stenosis, or aneurysmal dilation of the graft, arrow shows site of iliac anastomosis.

3. Results

From December 2011 till November 2016, 12 patients with aortic infective disease (11 AGI and 1 with mycotic aneurysm), there were 10 men and 2 women with mean age of 63±10 years. Demographic and clinical characteristics of patients are illustrated in table I.

Table I. Patient characteristics

	Total (n = 12)	%
Demographics		
Age (y) (mean) ±SD[a]	63 ± 10	
Men	10	83.3
Risk factors		
Smoking	8	66.6
Hypertension	8	66.6
Coronary disease	6	50
Hyperlipidemia	7	58.3
Diabetes mellitus	10	83.3
COPD[b]	1	8.3
Renal insufficiency	3	25
Steroid use	1	8.3
End stage renal disease	1	8.3
Emergency surgery	2	16.6
On IV[c] antibiotics	8	66.6
Presentation		
Open groin sinuses	5	41.6
Femoral pseudoaneurysm	6	50
Weight loss	2	16.6
Ischemia	3	25
Sepsis	9	75
AE erosion/fistula	0	0
Bleeding	1	8.3
Ankle-brachial index		
Preoperative (right)	0.75 ± 0.2	
Preoperative (left)	0.74 ± 0.3	
Infected graft configuration		
Aortofemoral grafts	10	83.3
Mycotic aneurysm	1	8.3
Aortoenteric fistula	1	83

[a]SD; standard deviation, [b]COPD; chronic obstructive pulmonary disease, [c]IV; Intravenous.

The mean ASA score was 3.6 0.8. Mean operative time was 5.3± 2.1 hours. Average estimated blood loss was 2.1 ±1 liters requiring 6 ± 3 blood units during surgery (table II). No evidence of reinfection in all patients during a mean follow up of 16 months (range 14-30 months), microbiological results are listed (Table III). One patient had postoperative pneumonia requiring ventilator support for extended period of time. One patients died postoperative due to myocardial infarction. One patient, with the femoro-tibial venous bypass graft, underwent an above-knee amputation because of occlusion of the graft (overall limb salvage rate 96%). One venous grafts thrombosed early in the postoperative period, managed by thrombectomy (table IV).

Table II. Operative data	
Operative data	**Total (n=12)**
[a]ASA class (Mean)	3±1
Duration (h)	5.3± 2.1
Blood loss (L)	2.1 ± 1.0
Transfusion blood (units)	6 ± 3
Transfusion crystalloid (L)	5 ± 2
Graft configurations	
Aortobifemoral	11
Aortobi-iliac	1
Concomitant Fem-pop/Distal bypass (patients)	1
[a]ASA; American Society of Anesthesiologists	

Table III. Microbiology		
	number	**%**
No growth	2	16.6
Single organism	7	58.3
polymicrobial	3	25
Type		
Gram positive	7	58.3
Gram negative	5	41.6
Anaerobes	2	16.6
Fungal	1	8.3

Table IV. Morbidity and mortality		
	number	**%**
Mortality	1	8.3
Length of stay (mean)	19 ± 8	
Surgical complications		
Graft thrombosis	1	8.3
Wound complications	2	8.3
Compartment syndrome	2	16.6
Amputations	1	8.3
Surgical bleeding	0	
Mesenteric ischemia	0	
Medical complications		
Reinfection	0	
DVT	1	8.3
Pulmonary embolism	0	
pneumonia	0	
Myocardial infarction	1	8.3
Stroke	0	

Postoperative limb swelling occur in all patients and managed by compression therapy, except in one patient who developed a popliteal vein thrombosis, treated by anticoagulants and later develop signs of

chronic venous hypertension. 2 patients developed compartment syndrome required fasciotomy. The mean follow-up was 16 months (range 14-30 months). Follow up duplex showed no dilatation, or stenosis of the graft. The mean length of stay was 19± 8 days.

4. Discussion

Mycotic aortic aneurysms are very rare and represent only (0.7%) of all aortic aneurysms.[6] AGI are relatively rare (0.5%-2% of aortic surgeries). 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%).[7] Deep veins of the lower extremity are a widely accepted conduit of choice for reconstruction in patients with AGI. Schulman and Badhey [8] first described use of a femoropopliteal vein segment as a vascular conduit for AGI. Clagett et al[9,10] have previously described creation of an aortic bifurcation by use of femoral vein as a "neoaortoiliac system." Femoral vein graft seems to be more resistant to infection despite being in a bacterial bath as no reinfection is encountered in all our patients. Beck et al[11] reported some dilation of venous graft, but we did not report any aneurysmal dilatation in all our patients but our follow up was limited by 30 months and long term follow up of graft diameter is required.

Acute rise in venous pressures in the leg after femoropopliteal vein harvest may result in compartment syndrome, requiring fasciotomy is reported by Wells et al[7] in up to one fifth of patients. To reduce the need for fasciotomy we limited femoral vein harvest to the adductor canal, to preserve the profunda vein and popliteal genicular draining veins, and we routinely used of intraoperative intermittent pneumatic compression. It is reported that approximately 35% of patients develop limb edema, which usually responds to elastic compression stockings.[11-13] All our patients develop postoperative lower limb swelling and resolved in most of cases by intermittent pneumatic compression followed by elastic stocking.

In order to determine the percentage of patients requiring fasciotomy and the predictors of the need for fasciotomy in patients undergoing FPV harvest Modrall et al reported that one in four patients undergoing FPV harvest for aortofemoral reconstruction expected to require fasciotomy. Risk factors include severe leg ischemia and GSV harvest in addition to FPV, recommending routine fasciotomy in patients with both risk factors.[14] In all our patients the femoral graft length was sufficient for bypass and we did not use GSV harvest in any of our patients. Verma et al[16] reported the use of GSV to further extend the pantaloon graft, and reported using alternative conduit configurations (such as aorto-unifemoral bypass plus femoro-femoral bypass).[16]

We used the pantaloons graft configuration as it restores the aortic bifurcation to its normal anatomic configuration, and solves the problem of size mismatch between the aorta and femoral vein.

Because prolonged operative time is a concern, a few surgeons prefer staging the vein harvest on the day before aortic grafting.[15] However, we used a two team approach to reduce operative time. One team explores the infected aortic graft, and the other team harvests and prepares the femoral vein graft. This strategy greatly limits the operative time.

We used a limited suture line just enough to create the union of the limbs of the pantaloons graft to reduces the time involved in creating the pantaloon graft.

The limb salvage rate reported in our study was 96%, and mortality rate was 8.3%, the primary patency of the graft was 81.7% and secondary or assisted patency was 100%. The reported 5-year cumulative primary patency of the aortic bifurcation reconstruction with femoropopliteal veins is 83%, and secondary or assisted patency is nearly 100%.[6,11] The limb salvage rate is 86%. Aneurysmal dilation of the venous conduit is rare.[6,11,13] Because of such encouraging outcome McKeever et al used femoral vein to revascularize failed aortobifemoral bypasses in the absence of infection in eight patients with promising results.[17]

We used reversed vein grafts so valve excision is not required, none of our patients develop graft stenosis, while Adam et al[18] used non reversed vein grafts after using a valvulotome to destroy the valves but they reported graft stenosis in three patients and the claimed that stenosis happened at the valve site.

Conclusions

Using FPV in pantaloon configuration for AGI treatment is an excellent conduit which is resistant to infection, permits use of smaller FPV diameter, with no need for excision of vein valves and provides excellent long-term patency. Our study is limited by the small number of cases and larger case series are required.

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