Primary Aortic and Vascular Graft Infections: Etiology, Diagnosis, Management and Prevention

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Disclosures

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Prosthetic Graft Infections

- Present as a spectrum of disease.
- Treatment should be individualized.
- Antibiotic therapy alone is inadequate.

- Incidence: 2 - 5%
- Late appearing infections are most common
- Higher if groin incision present
- 33 → 58% mortality rate
- 25 → 75% amputation rate
Incidence

- Relatively uncommon - 0.2-5%
- Influenced by implant site, indications for operation, host’s defense status, and patient’s comorbid disease.
- Aortic - 0.2%, femoropopliteal/tibial - 5%, and endograft 1%
- Emergency procedures higher
Microbiology

- **Staphylococcus aureus** - 25-50%
- **Staphylococcus epidermidis** - responsible for a significant proportion of graft infections, predominantly the late-appearing indolent type
Microbiology

- Proteases are secreted that cause this disruption along with the inflammatory response.
- Fungal infections occur in immunosuppressed patients.
Cause and Pathophysiology

- Intraoperative Contamination
- Hematogenous spread of bacteria
- Direct contamination of graft by infection emanating from skin, soft tissue, gastrointestinal tract, or genitourinary tract
Intraoperative Contamination

- Endogenous flora is a common source of graft infection
- The groin, due to large number of eccrine sweat glands, harbor large bacterial populations
- Lymphatics in groin may be contaminated at the time of surgery; especially if the patient has an open wound at the time of surgery
- Bacteria can be in diseased vessels or in the thrombus of AAA
Hematogenous Spread

- Frequency is uncertain
- Lower incidence of graft infection with a longer time after implantation- pseudointima
- Transient bacteremia (dental procedures or colonoscopy) may account for very late infections
Direct Contamination

- Easily diagnosed and least common
- An intra-abdominal abscess can directly infect a recently placed aortic graft
- Doing simultaneous gastrointestinal operations is not prudent- ? cholecystectomy
Prevention

- Antibiotics decrease the incidence of wound infections that could lead to graft infections
- Additional doses if case goes long
- Prolonged use of postoperative antibiotics may be detrimental
Prevention

- Meticulous surgical technique
- Adhesion drapes
- Irrigation
- No simultaneous gastrointestinal operations-unplanned enterotomy
- No evidence to support of soaking grafts in antibiotics
## Graft Infections

### Antibiotic Dosing
- Every 4 hours intraoperative (cefazolin)
- Until all lines are out (?)
- Low cost
- Topical antibiotics easy to use

### Postoperative Antibiotic Coverage
- Oral antibiotics
- Colonoscopy
- Cytoscopy
- Dental procedures
- Urinary catheterization
The vascular graft is vulnerable to circulating bacteria when it is unprotected by a complete and stable pseudointima.

Moore, et al
Prosthetic Graft Infections

Early Infections

- Grade I: Cellulitis (skin only)
- Grade II: Subcutaneous tissue
- Grade III: Prosthesis itself
Prosthetic Graft Infections

Occult infection

- Poses enormous difficulties in the determination of the extent of graft involvement

*Low incidence of systemic symptoms

- Often demonstrates that these findings do not correlate with the amount of graft involved by infection

* fever, leukocytosis, sepsis
Prosthetic Graft Infections

- Early (<6 months)
  - Fever
  - Leukocytosis
  - Bacteremia
  - Wound infection
  - Anastomotic bleeding

*Most common Staphylococcus aureus*
Prosthetic Graft Infections

- Late (25→70 months mean)
  - Fever, malaise, septic emboli, sedimentation rate or leukocytosis
  - CT scan is essential to look for air or fluid around the graft or pseudoaneurysm at the anastomosis
  - GI hemorrhage: herald bleed or chronic bleeding
  - Sinus tract: 30→70%
  - Graft thrombosis: 8→20%
Prosthetic Graft Infections

- **Diagnostic Tests**
  - Endoscopy for acute bleeding
  - CT scan
  - Angiography
  - Ultrasound
  - WBC scans
  - WBC count
  - Sed rates
  - Blood cultures
  - Cultures of sinus tract and fluid
  - MRI – $T_2$
PRIMARY AORTIC AND VASCULAR GRAFT INFECTIONS

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Prosthetic Graft Infections

- Operative Assessment
  - Graft incorporation
  - Presence of fluid/cultures
  - Gram stains
  - Tissue debridement/coverage with muscle and soft tissue
Prosthetic Graft Infections

- Treatment Considerations
  - Clinical presentation
  - Anatomic location of infectious process
  - Extent of graft infection
  - Identity and virulence of infecting organism
  - Status of host defense mechanisms

Treatment Options

- Graft excision and extraanatomical bypass
- Graft excision and in situ replacement
- Local, nonexcisional therapy with graft preservation
Prosthetic Graft Infections

- Graft excision *if*: 
  - Presentation with hemorrhage
  - Exploration reveals gross contamination
  - High numbers of virulent bacteria are present (>10^5 of *pseudomonas* or *S. aureus*)
  - Entire prosthesis involved
Prosthetic Graft Infections

Aortic stump must be debrided. Two layer closure cover with omentum antibiotics forever.

PRIMARY AORTIC AND VASCULAR GRAFT INFECTIONS
Prosthetic Graft Infections

- Can stage extraanatomic bypass
  - Followed by graft removal

- Can replace extraanatomic bypass with delayed in-line reconstruction
  - If graft failure occurs in the first few years
  - And no recurrent infection is apparent
Prosthetic Graft Infections

- *In situ* replacement with autogenous conduits
  - SFA artery
  - Iliac artery
  - Saphenous vein grafts
  - Superficial femoral veins

- Complex
- Difficult
- Use with less virulent organisms
Prosthetic Graft Infections

- Local, nonexcisional therapy with graft preservation

Groin or distal grafts most applicable

Suture lines not involved

Use muscle flaps, good debridement
In Situ Replacement: Recommendations

- Patient must have correct diagnosis.
- Graft must be TOTALLY excised.
- Muscle coverage is important.
- Treat lymphoceles aggressively.
- Use PTFE as the replacement graft.
Aortoduodenal Fistulas: *Mechanisms*

- **Mechanical**
  - Bleeding with pseudoaneurysm
  - Excessive tension on the graft or duodenum

- **Nonmechanical**
  - Infection
Aortoduodenal Fistulas: *Mechanisms*

- Overall incidence: 0.4–2.4%
- 87–93% are secondary
  - \(\frac{1}{4}\)–\(\frac{1}{2}\) of graft infections
- Mostly the duodenum
- 12% jejunum
- 8% cecum
- 4% appendix
PRIMARY AORTIC AND VASCULAR GRAFT INFECTIONS
Aortoenteric Fistula: Diagnosis

- “Herald” bleeding
- Massive hemorrhage
- GI bleeding
- Chronic GI bleeding
- Positive blood cultures
- Abdominal pain

Chronic

- Fever and chills
- Splinter hemorrhages
- Septic emboli
- Sedimentation rate
- White blood cell count
Aortoduodenal Fistulas: *Diagnosis*

- Endoscopy
- CT scan
- Angiography
- Colonoscopy
- Exploratory laparotomy
Aortoduodenal Fistulas: Treatment

- Control bleeding
- Excise graft and debride aortic stump
- Repair enterotomy
- Debride retroperitoneum
- Extra-anatomic bypass
The use of cryopreserved aortoiliac allograft for aortic reconstruction in the United States

MP Herlander-Locke, LK Harmon, PF Lawrence, GS Oderich, RA McGready, MD Morach, RJ Feezor

The Vascular Low-Frequency Disease Consortium

220 Patients (Mean age 65; Male:Female 1.6/1) between 2002-2013

– Culture Positive (60%)
– Culture Negative (16%)
– Enteric erosion/fistula (15%)
– Infected pseudoaneurysm (4%)
– Other (4%)
– Intraoperative cultures (66%)
Results

- LOS 24 days
- 30 day mortality: 9%
- Complications: 24%
  - Sepsis 17
  - CAA Thrombosis 9
  - CAA Rupture 8
  - Recurrent CAA Infection 8
  - CAA Pseudoaneurysm 6
  - Recurrent Aortoenteric fistula 4
  - Compartment Syndrome 1
Results
Mean follow-up 30 +/- 3 months

- Freedom from at 5 years:
  - Graft related complications 80%
  - Graft explant 88%
  - Limb loss 97%
  - Primary graft patency 97% at 5 years
  - Patent survival 75% 1 year; 51% 5 years
•Largest Study
•Short follow-up
•First line treatment of aortic graft infections
In situ bypass and extra-anatomic bypass procedures result in similar survival in patients with secondary aortoenteric fistulas


Methods

• Retrospective, multi-institutional study of SAEF 2002-2014 using a standard database

• Primary outcome was mortality.

• Kaplan-Meier analysis, and univariate and multivariate analysis were performed.
Results

• 182 patients at 34 institutions from 11 countries

• Median age 72 years; 79% male

• 138 (76%) surgical grafts; 42 (23%) endografts; 2 unknown

• 102 (56%) complete excision with in situ bypass
  • antibiotic soaked prosthetic (53)
  • autogenous femoral vein (17)
  • cryopreserved allograft (28)
  • untreated prosthetic graft (4)

• 80 (44%) extra-anatomic bypass with infected graft excision
Results

• Overall median Kaplan-Meier estimated survival – 319 days (20-2410 days)

• Stratified by EAB vs ISB – no difference (p = .82)

• EAB patients were older (74 vs. 70 years p = .01)
  • Less operative hemorrhage (1200 vs. 200 ml p = .04)
  • More likely to initiate dialysis within 30 days post op (15% vs. 5% p = .02)
  • Less likely to experience aorta related hemorrhage 30 days post op (3% aortic stump dehiscence vs 11% anastomotic rupture p = .03)

• Multivariable Cox regression showed that the duration of antibiotic use and rifampin use independently decreased mortality.
Conclusions

• ISB does not offer a survival advantage compared with EAB and does increase postoperative aortic-related hemorrhage.

• After repair, <50% of SAEF survive 10 months.

• Each week of antibiotic use decreases mortality by 8%.
Outcomes of unilateral graft limb excision for infected aortobifemoral graft limb.

JD Crawford, GJ Landry, GL Moneta, EL Mitchell


- Presentation
  - Cellulitis – 10
  - Pseudoaneurysm – 2
  - Ilioenteric fistula – 1
  - Ruptured appendicitis – 2
15 Patients (2001-14) – 10M 5F

- Occlusive disease – 73%
- Smoker – 93%
- Age when graft was placed – 61 +/- 7.4
- Age when infected – 68 +/- 6.9
- Mean time to infection – 73.5 months
7 developed contralateral limb infection at median follow-up 23.2 months after unilateral excision

Factors predictive of contralateral infection were aortoiliac occlusive disease and culture evidence of infection above inguinal ligament

Organisms or antibiotics did not predict contralateral limb infection

40% mortality overall at 44.7 months
Early outcomes of native and graft-related abdominal aortic infection managed with orthotopic xenopericardial grafts


Methods

• 21 consecutive patients (mean age 69 years; 20 male) who underwent abdominal xenopericardial in situ reconstruction of native aortic infection (4); endovascular (4) or open (13) graft aortic infection between 2017-2019.

• Non ruptured; all urgent.
Results

• 8 with xenopericardial tubes and 13 with bifurcated grafts
• 30 day mortality 4.7% (1 pneumonia)
• 6 patients developed acute kidney injury – 4 requiring temporary dialysis – 5 recovered – 1 died.
• 4 required return to OR group
• Median follow up 14 months (1-26)
  • Mortality 19% (4)
    • 2 had current sepsis and multiorgan failure and death
• CT scans of 16 others showed no stenosis or graft dilation and 1 asymptomatic left branch thrombosis
Conclusions

• Small series with native and graft-related infections.

• Gram negative organisms were in the recurrent sepsis and return to
Should extra anatomic bypass remain the gold standard for treatment of aortic graft infections?

- Length of time of procedure
- Failure of graft
- Long-term follow-up
- Availability of appropriate graft
- Graft degeneration
- Graft reinfection
## Endovascular Stent Infections

### Experimental evidence

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<th>Group</th>
<th>Details</th>
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| Group A  | Prophylactic cefazolin given at time of stent deployment plus intraaortic *S. aureus* challenge  
          | 2/7 had positive cultures (control 7/10)                                                    |
| Group B  | Prophylactic cefazolin given at time of stent deployment plus IV *S. aureus* 4 weeks later  
          | 1/10 had positive cultures (control 7/14)                                                    |
| Group C  | IV *S. aureus* 3 months after stent deployment                                               
          | 1/15 had positive cultures                                                                   |
Endovascular Stent Infections

- Presenting Clinical Features
  - Localized pain, swelling, erythema ipsilateral leg
  - Purpuric rash may be present
  - Fever, sweats and lethargy
  - Leukocytosis
  - Anemia (normocytic)
  - Renal impairment
  - Positive blood cultures
Endovascular Stent Infections

- Organism
  - *Staphylococcus aureus*
  - *Staphylococcus epidermidis*

Similar to Vascular graft infections
Endovascular Stent Infections

- Pathophysiology
  - A necrotizing angiitis that occurs at the site of the stent with erosion through the vessel
  - Can spread hematogenously
Endovascular Stent Infections

- Treatment
  - High dose intravenous antibiotics
  - Surgical resection of the stent
  - Autogenous reconstruction if possible in a remote site, i.e., fem-fem bypass
  - May require amputation
Endovascular Stent Infections

- **Prevention**
  - Good skin prep
  - Working in sterile environment
  - Scrubbing, masks, gowns and gloves for the interventionalist
  - Prophylactic antibiotics
  - Minimal handling of the stent
Treatment and outcomes of aortic endograft infection

MR Smeds, AA Duncan, MP Harlander-Locke, PF Lawrence, S Lyden, J Fatima, MK Eskandari, and the Vascular Low-Frequency Disease Consortium


- EVAR or TEVAR infections 2004-2014
  - 206 patients (161 M, 45 F)
  - 68 +/- 9 years
  - EVAR – 180
  - TEVAR – 26
  - Diabetes 26%
  - Chronic infections 15%
  - Immunosuppression 4%
Clinical Presentation at a mean of 22 months

- Pain 60%
- Fever/chills 66%
- Aortic Fistula 27%
- Infection following operation 38%
- Infection at initial operation 34%
- Contaminated 14%
- Endoleak 25% - Treated 56%
Surgical Management

- 197 (96%)
  - 19% (37) urgent - 49% (18) rupture, 43% (16) endoleak, 24% (9) aortic fistulas
  - Dacron graft 75 (38%)
  - Cryopreserved 54 (27%)
  - PTFE 36 (18%)
  - NAIS 21 (11%)
  - Extra anatomic 11 (6%)
Bacteriology

- 42 (22%) gram positive (Streptococcus)
- 25 (13%) gram negative (E. Coli and Bacteroides)
- 8 (5%) fungus
- 66 (35%) polymicrobial
- 56 (30%) negative
Antibiotics

- Indefinitely 122 (62%)
  - Remaining patients treated 165 days (11-1825 days)
Outcomes

- 5 replacement grafts ruptured
- 30 day period mortality 11%
- 5 year survival 51%- better with autologous
A multicenter experience with the surgical treatment of infected abdominal aortic endografts.


- 36 patients (30 m) 1997-2014
  - Median age 69 (54-80)
  - Presentation 569 days (43-2466)
  - Leukocytosis 23, pain 21, fever 20

J Vasc Surg 2015; 63: 877-83
Treatment

- 34 total graft excision
- 27 in situ (all types)
- 9 extra anatomic
Bacteriology

- Gram positive 24 (67%)
  - Staphylococcus 13 (36%)
  - Streptococcus 6 (17%)
- Anaerobes 6 (17%)
- Gram negative 6 (17%)
- Fungus 5 (14%)
- Negative 8 (22%)
Mortality

- Perioperative 8% (3)
- Long-term 25% (9) at mean 569 days (0-3079 days)
- Type of reconstruction did not influence death
“Life is a succession of lessons which must be lived to be understood.”

Ralph Waldo Emerson