Aortic Graft Infection—Contemporary Management of a Resurgent Problem

Peter F. Lawrence, MD
Professor and Chief
Division of Vascular Surgery
University of California Los Angeles

Incidence of Aortic Graft Infection

- Meta-analysis - 13 series with 11,526 aortic grafts
- 1.6% incidence; highest with aortofemoral graft
- Aortoenteric fistula/erosion - 0.75%
- Underestimates true incidence
- Projected infections - 95,000 grafts x 1.6 = 1,520/year

Sarfati - Epidemiology of Aortic Graft Infection in Gewertz Surgery of the Aorta

Evolution of Aortic Graft Infection

- Incidence of Aortic Graft Infection

High mortality:
- One year survival - 65%; 5 year survival - 55%
- Early mortality: sepsis, MSOF, hemorrhage, renal failure, MI
- Late mortality: Graft related (recurrent infection), CV disease
- Mortality declining

Morbidity
- Limb loss - 20%
- Pneumonia, renal failure, cardiac - 60%
- Reoperation - 20%
- Re-infection of new graft – 20-60%
- Occlusion of new graft - 25%
Endograft Infection: The New Epidemic?

- Increasing reports of endograft infection (~35 papers since 2005)
- Incidence ranges from 0.2 to 0.7%
- 1431 aortic endografts placed evaluated with 11 endograft infections (EVAR + TEVAR)= 0.6%

Diagnosis – Direct Culture and Graft Exploration

- Infected grafts show lack of incorporation, purulent exudate, and a perigraft capsule
- Absence of incorporation is “gold standard”
- Gram stain may help with operative decision
- Graft culture may include sonication

Diagnosis: Computed Tomography

- Characteristic appearance - collections of fluid or air around graft
- Air and fluid are normal immediately postop, but diminish over time
- Lack of air and fluid helps exclude graft infection

Diagnosis: Endoscopy

- GI bleeding common following aortic surgery (21%)
- GEF comprise only 1% of GI bleeders
- Endoscopy indicated in all stable patients with an aortic prosthesis and GI bleeding
Diagnosis: DSAngiography (or CTA/MRA)
- Identifies graft infections associated with anastomotic false aneurysms and graft occlusions
- Nonspecific for graft infection
- Useful in planning surgery for stable patients

Diagnosis of Aortic Graft Infection: Radiologic Nuclide Scans (Indium 111)
- Useful in stable patients
- Depends on intense inflammatory response, so better for virulent bacteria
- Confirms presence or absence of infection
- Determines extent of infection
- May identify other sites of infection
- + for 2-3 weeks postop in normal patients
- PET and SPECT scan being reported in Europe for 3-D scanning

Indium 111 Leukocyte Diagnosis of Aortic Graft Infection

<table>
<thead>
<tr>
<th>Scan</th>
<th>+</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>-</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

Indeterminate = 4

Lawrence, PF. J. Vasc Surg 1985

Typical Patient
- 57 YO woman underwent uncomplicated aorto-bifemoral bypass with PTFE for claudication in 2004
  - Severe rheumatoid arthritis,
  - Rx’ed with steroids-24 ops
  - Heavy smoker for 45 years
  - + troponins in post op period
  - Post op right groin infection
  - Rx’ed with sartorius muscle flap
- Two month history of spontaneous drainage from right inguinal region
- Recent left groin erythema
Treatment
Less Invasive Approaches

- IV / topical antibiotics
- Muscle coverage without graft excision
- Drainage with Abx irrigation
- VAC
- Replacement with Abx bonded femoral graft
- Never “cure” infection

Seminars in Vascular Surgery 2011

Definitive Graft Infection Treatment – Excision Without Revascularization

- Entire graft removal is conventional approach: revascularization not always required
- If graft thrombosed, then removal alone is OK
- May also work when indication was claudication or proximal anastomosis was E-S
- Aortic aneurysms unlikely to tolerate graft removal alone
- 15/101 patients in one series not revascularized

Test to Determine Revascularization Need

- Segmental pressures for multilevel disease
- Ankle pressure > 40 and ABI with graft occlusion/compression
- Ankle pressure > 40 and ABI with angiographic balloon occlusion

Graft Excision with Extra-anatomic Revascularization

- 1st described by Blaisdell in 1961
- Gold standard for aortic infection involving more than isolated area of graft
- Early results resulted in 40% mortality and 25% amputation
- Recent results with improved anesthesia and sequencing of procedures have 25% mortality
Staged Treatment of Aortic Graft Infection

- Revascularization precedes graft excision by 1-2 days
- Eliminates period of prolonged ischemia
- Allows for better hemodynamic stability
- Rests surgical team
- Does not result in increased graft infection rate

Reilly J Vasc Surg 1987

Extraanatomic Bypass

- Graft Thrombosis: 10-20% at 5 years
- Graft Residual or reinfection: 5-20% at 5 years
- Aortic stump disruption: 0-5%, but may occur years later


Revascularization with Autogenous Tissue (venous)

Jicha, Reilly, Goldstone JVS 1996

Prosthetic Insitu Replacement

- Not appropriate when suture line is involved with bleeding
- Major risk is recurrent infection
  - Debridement of infected aortic wall is critical
- Most appropriate for patients with normal defenses and no extensive purulence
- Best prosthesis is antibiotic bonded Dacron, using Rifampin with a gelatin bond

Lachapelle J Vasc Surg 1994
**In Situ Replacement with Femoral Veins (NAIS)**

Popularized by Claggett and colleagues at Southwestern “Neoaortoiliac system” (NAIS)

---

### NAIS Results

<table>
<thead>
<tr>
<th>Study</th>
<th>Patients (n)</th>
<th>Follow-Up (Months)</th>
<th>30-day Mortality</th>
<th>Major Amputation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claggett (1993)</td>
<td>21</td>
<td>23</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Ehsan (2009)</td>
<td>48</td>
<td>56</td>
<td>2%</td>
<td>0%</td>
</tr>
<tr>
<td>Ali (2009)</td>
<td>144</td>
<td>32</td>
<td>10%</td>
<td>7%</td>
</tr>
</tbody>
</table>

---

### Insitu Revascularization with Allograft

- Reported 9% mortality and 5% amputation rate
- Used with all organisms
- Peripheral edema occurs, but usually controllable
- Good durability
- Long procedure (10-12 hrs)

Clagett GP J Vasc Surg 1997

---

### Allograft replacement for infrarenal aortic graft infection: Early and late results in 179 patients

Edouard Kieffer, MD, Dominique Gomes, MD, Laurent Chiche, MD, Marie-Hélène Pléven, MD, Fabien Koskas, MD, and Amine Bahimi, MD, Paris, France

- Mean age = 65 ± 9 years
- Indication for allograft use:
  - Primary graft infection (n=125, 70%)
  - Secondary aorto-enteric fistula (n=54, 30%)
- 62% of patients underwent 3 ± 2 repeat operations before allograft replacement

- 1988-2002
- 179 Patients
  - Fresh allograft: 111 Patients
  - Cryopreserved allograft: 68 Patients

---
Kieffer E, et al

Late mortality = 25.9% (allograft-related = 2.1%)
- All 3 patient deaths were due to allograft rupture at 9, 10, and 27 months.
- 2 patients received fresh allograft (66%)

Cyropreserved Allograft

Previous aneurysm concerns have been addressed with changes in preservation
Options include Cryovein and Cryoartery
Expensive- are Cryoartery costs justified by better outcomes?

Advantages of CryoArtery vs. Cryovein for In-Line Reconstruction

- Thicker wall vs. vein conduit
  - Durable material- less rupture risk
  - Less risk for recurrent infection
- Excellent fit: available as bifurcated conduit
- Expensive but cost-competitive
  - Does not require time in OR for construction of neo-aortoiliac segment

Duncan, et al, Allograft registry; JVS 2003

Uses of Allograft
Technique

- Need proximal and distal control above and below the infection
- Often requires supra-renal clamping
- Opening the retroperitoneum may still result in significant bleeding
- Necrotic tissue requires debridement
- Sew up to the orifices of the renal arteries
- Occasionally need autogenous transplant of renal arteries

Aortic Graft Infection: Single-Institution (UCLA) Experience

<table>
<thead>
<tr>
<th>Table 3: Organisms Detected from Explanted Aortoiliac Grafts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organism</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Staphylococcus aureus</td>
</tr>
<tr>
<td>Staphylococcus epidermidis</td>
</tr>
<tr>
<td>Proteus mirabilis</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
</tr>
<tr>
<td>Candida albicans</td>
</tr>
<tr>
<td>Escherichia coli</td>
</tr>
<tr>
<td>Enterobacter cloacae</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4: Outcomes after In-line Reconstruction of Atherosclerotic Aortic Prosthetic Graft Infections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mortality</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>Pseudoneurosurger with limb loss</td>
</tr>
<tr>
<td>Colon perforation</td>
</tr>
<tr>
<td>Limb ischemia</td>
</tr>
<tr>
<td>Compartment syndrome</td>
</tr>
</tbody>
</table>

Table 5: Collected Series on In-line Reconstruction for Atherosclerotic Aortic Prosthetic Graft Infections

<table>
<thead>
<tr>
<th>Series</th>
<th>n</th>
<th>Condition Type</th>
<th>Causal Location</th>
<th>Recurrent Infection %</th>
<th>30-Day Mortality %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zenati et al.</td>
<td>62</td>
<td>BFA</td>
<td>Abdominal</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Tiedmann et al.</td>
<td>64</td>
<td>BFA</td>
<td>Abdominal, lumbar and iliac</td>
<td>0</td>
<td>15</td>
</tr>
<tr>
<td>Snyder et al.</td>
<td>76</td>
<td>BFA</td>
<td>Abdominal</td>
<td>0</td>
<td>12.5</td>
</tr>
<tr>
<td>Levinson et al.</td>
<td>46</td>
<td>BFA</td>
<td>Abdominal</td>
<td>0</td>
<td>13.6</td>
</tr>
<tr>
<td>Vlahakis et al.</td>
<td>14</td>
<td>BFA</td>
<td>Abdominal, lumbar, and iliac</td>
<td>0</td>
<td>18</td>
</tr>
<tr>
<td>Snyder et al.</td>
<td>57</td>
<td>BFA</td>
<td>Abdominal, lumbar, and iliac</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Table 6: Causes of Atherosclerotic Aortic Prosthetic Graft Infections</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Morbidity</td>
<td>n</td>
<td>%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudoneurosurger with limb loss</td>
<td>1</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colon perforation</td>
<td>1</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limb ischemia</td>
<td>1</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compartment syndrome</td>
<td>1</td>
<td>4.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Explanted Graft
Results

220 Patients at 14 institutions (M:F = 1.6/1, Mean age = 65±12 yrs)

Type of Initial Aortic Procedure | n (%)  
--- | ---  
Open reconstruction | 209 (95%)  
Endovascular | 11 (5%)  

Indication for Use of CAA | n (%)  
--- | ---  
Prosthetic graft infection | 134 (61%)  
Primary abdominal aortic infection | 35 (16%)  
Graft enteric fistula/erosion | 33 (15%)  
Infection pseudoaneurysm | 9 (4%)  
Other, including high risk of graft infection | 9 (4%)  

Procedure Details

Operative Variable (N=220) | n (%)  
--- | ---  
Graft Excision  
Full excision | 149 (68%)  
Distal Anastomosis  
Bilaterally to external iliac artery | 139 (63%)  
Bilaterally to femoral artery | 66 (30%)  
Unilateral to femoral and external iliac artery | 15 (7%)  
Concomitant Procedures with CAA Placement  
Femoral artery to distal artery bypass | 42 (19%)  
Duodenal repair or colon resection | 7 (3%)  
Other vascular procedures | 32 (15%)  

Technique

Early and Late Complications

Complication (n = 55) | n (%)  
--- | ---  
Persistent sepsis | 17 (8%)  
CAA thrombosis/occlusion | 9 (4%)  
CAA rupture | 8 (4%)  
Recurrent CAA infection | 8 (4%)  
CAA pseudoaneurysm | 6 (3%)  
Fistula recurrence | 4 (2%)  
Lower extremity compartment syndrome | 1 (<1%)  
Colonic perforation | 1 (<1%)  
Lower limb ischemia | 1 (<1%)  

Mean follow-up = 30 ± 3 months  
Range = 1 to 160 months
Factors Associated with Graft Related Complications

31 Patients (15%) had CAA related complications

<table>
<thead>
<tr>
<th>Factor</th>
<th>Hazard Ratio</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 70</td>
<td>1.657</td>
<td>1.286 – 2.131</td>
<td>.003</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>2.050</td>
<td>1.094 – 4.466</td>
<td>.027</td>
</tr>
<tr>
<td>Virulent Organism</td>
<td>2.423</td>
<td>1.821 – 3.096</td>
<td>.038</td>
</tr>
<tr>
<td>Prosthetic graft excision:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial</td>
<td>3.500</td>
<td>.984 – 12.446</td>
<td>.053</td>
</tr>
<tr>
<td>Emergent Surgery</td>
<td>.681</td>
<td>.263-1.763</td>
<td>.429</td>
</tr>
</tbody>
</table>

Indications for CAA:

| Prosthetic graft infection      | .898         | .194 – 4.165            | .891    |
| Enteric fistula/erosion         | 1.920        | .749 – 3.923            | .175    |
| Primary aortic infection        | 2.481        | 1.283 – 21.760          | .297    |

Graft Explant

<table>
<thead>
<tr>
<th>Indication</th>
<th>Duration of CAIG Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAA Infection</td>
<td>73 months</td>
</tr>
<tr>
<td>CAA Infection</td>
<td>51 months</td>
</tr>
<tr>
<td>CAA Aneurysm</td>
<td>40 months</td>
</tr>
<tr>
<td>CAA Stenosis</td>
<td>38 months</td>
</tr>
<tr>
<td>CAA Aneurysm</td>
<td>23 months</td>
</tr>
<tr>
<td>CAA Infection</td>
<td>11 months</td>
</tr>
<tr>
<td>CAA Pseudaneurysm</td>
<td>10 months</td>
</tr>
<tr>
<td>CAA Pseudaneurysm</td>
<td>5 months</td>
</tr>
<tr>
<td>CAA Infection</td>
<td>7 days</td>
</tr>
</tbody>
</table>

Mean follow-up = 30 ± 3 months
Range = 1 to 160 months

Factors Associated with CAA Graft Explant

10 Patients (5%) had CAA explant

<table>
<thead>
<tr>
<th>Factor</th>
<th>Hazard Ratio</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 70</td>
<td>1.390</td>
<td>1.081 – 5.883</td>
<td>.041</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>1.561</td>
<td>.145 – 3.048</td>
<td>.182</td>
</tr>
<tr>
<td>Prosthetic graft excision:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partial</td>
<td>3.222</td>
<td>1.357-29.054</td>
<td>.007</td>
</tr>
<tr>
<td>Complete</td>
<td>.494</td>
<td>.134-1.818</td>
<td>.288</td>
</tr>
<tr>
<td>Emergent Surgery</td>
<td>.705</td>
<td>.145-3.420</td>
<td>.664</td>
</tr>
</tbody>
</table>

Indications for CAA use:

| Primary Aortic Infection        | 2.481        | 1.283-21.760            | .138    |
| Enteric Fistula/Erosion         | 1.618        | .155-2.457              | .494    |
| Prosthetic Graft Infection      | 1.179        | .295-4.716              | .816    |

Patient Survival, Graft Patency, and Limb Loss

<table>
<thead>
<tr>
<th>At Risk:</th>
<th>N=122</th>
<th>N=91</th>
<th>N=65</th>
<th>N=54</th>
<th>N=46</th>
<th>N=35</th>
<th>N=27</th>
<th>N=22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cumulative Survival:</td>
<td>95%</td>
<td>90%</td>
<td>95%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Primary Graft Patency:</td>
<td>95%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>Freedom from Limb Loss</td>
<td>95%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
</tr>
</tbody>
</table>

Mean follow-up = 30 months; Range = 1 to 160 months
Infected Abdominal Aortic Endograft

- Usually total graft involvement
- Aneurysm or pseudoaneurysm above infected graft
- Often significant periaortic inflammation

Mayo Clinic Experience
Infected Abdominal Aortic Endograft

From the Midwestern Vascular Surgical Society

Treatment strategies and outcomes in patients with infected aortic endografts

José M. Alfonso, MD, Andrea A. Dunbar, MD, Ellis de Geus, MD, Alfonso A. Alhadefo, MD, Marjeta Kuk, MD, Peter Krieger, MD, and Thomas F. Brennan, MD, Anesthesiology

JVS 2013;58:371-379

Frank purulence

Indium 111-labelled WBC scan
**Infected Abdominal Aortic Endograft**

A 79 year-old man with infected abdominal aortic endograft

- Recurrent UTIs
- Salmonella septicemia 4 years after EVAR
  - Psoas abscess
- Significant cardiac disease

**Surgical Treatment**

- Drainage of abscess and IV antibiotics
- Temporary axillo-femoral bypass
- Staged excision of endograft, aorto-iliac homograft, and aortic wall debridement

**Coming soon...2015 SVS VAM**

The Vascular Low Frequency Disease Consortium

Title: Treatment and Outcomes of Aortic Endograft Infection

Authors: Andrea Duncan MD, Matthew Smoels MD, Michael Harlander-Locke MPH, Peter Lawrence MD, Sean Lyden MD, Ibraheem Fatma MD, Kristine Charlton-Chew MD, Mark Munro MD, Ragho Moteagalinahalli MD, Peter Nelson MD, Sherene Shafikhani MD, Paul Bove MD, J. Gregory Montrail MD, Victor Stovila MD, Nazim Hedgley MD, Almed Aboz-Zamzam MD, Christopher Abolarraga MD, Catherine Wittgen MD

- 202 Patients from 18 institutions
  - EVAR = 176
  - TEVAR = 26
- Standardized multi-institutional database
  - Medical and surgical management
## Treatment

<table>
<thead>
<tr>
<th>Medical Management</th>
<th>Number (n, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only antibiotics</td>
<td>8, 4%</td>
</tr>
<tr>
<td>Converted to surgical</td>
<td>21, 10%</td>
</tr>
</tbody>
</table>

### Surgical Management

<table>
<thead>
<tr>
<th>In-line Reconstruction</th>
<th>Number (n, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryoartery</td>
<td>47, 23%</td>
</tr>
<tr>
<td>Dacron</td>
<td>46, 23%</td>
</tr>
<tr>
<td>PTFE</td>
<td>36, 18%</td>
</tr>
<tr>
<td>Dacron (antibiotic)</td>
<td>26, 13%</td>
</tr>
<tr>
<td>NAIS</td>
<td>21, 10%</td>
</tr>
<tr>
<td>Cryovein</td>
<td>7, 3%</td>
</tr>
</tbody>
</table>

## Extra-Anatomic

<table>
<thead>
<tr>
<th>Number (n, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ax-(b)ilem bypass</td>
</tr>
</tbody>
</table>

## Symptoms

- Pain (54%); Fever/chills (47%)
- Weight loss (20%)

## Graft cultures

- top = polymicrobial, fungal

## Mean LOS = 24 days

## Early Complications

- Renal failure (19%)
- Persistent sepsis (12%)
- MI (5%)
- Recurrent infection (5%)
- Pneumonia (4%)

## Graft explants

- 19 (10%) after mean 540 days

**Early graft related mortality 6%; graft related late mortality 23%**

## Conclusions

- Graft infections will continue to occur in 1-2% of patients undergoing prosthetic revasc, causing 1-2 thousand infections per year
- **Endografts are increasingly responsible for graft infections**
- The diagnosis of graft infection usually requires imaging studies (CT/CTA, WBC scan, endoscopy) to establish the existence and extent
- Treatment may range from antibiotics alone to graft replacement to excision and rerouting of the graft
- The morbidity (amputation, renal failure) and mortality remain high
- With graft excision and extra-anatomic revascularization, better results can be obtained with staged operations in stable high risk patients
- **Replacement of infected prosthetic grafts with autogenous in-line grafts offers an excellent likelihood of survival and long term success**