INTRODUCTION

Despite antibiotic prophylaxis and the development of more refined surgical techniques, microbial infection of the vascular prostheses are well known, not rare and redutable complications. The literature-reported incidence may vary between 0.2 and 5% and it is influenced by the site of the implant, the underlying disease and the host defense mechanism. Infection affects especially prosthetic grafts which are implanted during emergency procedures (for example emergency surgery for the ruptured abdominal aortic aneurysm) and prostheses anastomosed to the femorala artery or placed into a subcutaneous tunnel (for example the axillofemoral or axillofemoral grafts).

Vascular graft infections are classified by their appearance time (early infections-which appear earlier than 4 months after graft implantation; late infections-which appear after 4 months), their relationship to the postoperative wound and the extent of graft involvement.

Szilagyi’s classification [2] is refering to the grades of postoperative’s wound infection. So we have three grades, as follows:

- grade I: cellulitis involving wound;
- grade II: infection involving subcutaneous tissue;
- grade III: infection involving the vascular prosthesis.

An early infection correlates with a Szilagyi grade III wound infection. These infections are caused by virulent hospital-acquired bacteria and present with sepsis signs like: fever, leukocytosis, bacteremia and easy noticeable signs of an infected wound (inflamated tissues around it, pus emerging from it).

Late infections are a result of graft colonization by “low-virulence” organisms such as: Staphylococcus epidermidis or Candida spp. They are characterized by the fact that they are indolent and have no signs of sepsis and cultures of the perigraft tissues are not growing any germs.

IV.1. Pathogenesis of graft infection

The initiating event is the bacterial adherence to the biomaterial surfaces, followed by colonization and development of a bacterial biofilm that resists host defenses and antibiotic penetration.

**The presence of a foreign body potentiates the infectivity of bacteria.** Elek [1] and Cone demonstrated in 1957 that a single-stranded silk suture significantly reduced the inoculum of staphylococci required to produce a local infection. The risk of foreign body infection can be predicted by the formula:

\[
\text{Risk of biomaterial infection} = (\text{Dose of bacterial contamination} \times \text{virulence}) / \text{Host resistance}
\]

**Bacterial adherence to polyester grafts is 10 to 100 times greater than to PTFE grafts.** Gram-positive bacteria produce an extracellular glycocalix made out of mucine which makes them much more adherent than Gram-negative ones.

**Risk of biomaterial infection**
In some vascular centers, prophylactic antibiotics are continued for 3 to 5 days in patients being at high risk for infection from bacteremia, prolonged preoperative hospitalization or high institutional wound infection rates (>10%).

IV.3 Bacteriology

S. aureus is the most prevalent pathogen, one fourth of prosthetic infections being caused by it. Lately, prosthetic infections caused by S. Epidermidis or Gram-negative bacteria have emerged. This change in the microbiology of graft infections is the result of reporting both early and late infections and of surgeons becoming more aware of the false-negative microbiological results taken from many late infections, owed to the low bacteria numbers present within the graft surface biofilm.

Graft infections associated with negative culture results are caused by S. epidermidis or other coagulase-negative staphylococci or by Candida species. Infections due to Gram-negative bacteria as E. Coli, Pseudomonas, Klebsiella, Enterobacter and Proteus spp are very virulent.

The incidence of anastomotic dehiscence and artery rupture is high and is due to the ability of these organisms to produce destructive endotoxins. Fungal infections are very rare and most of the patients having them are immunosuppressed or have an established fungal infection elsewhere.

MRSA is responsible for one fourth of early graft infections nowadays. This recent increase in MRSA graft infections may justify the use of specific antibiotic prophylaxis for all vascular implant procedures.

Infection diagnosis is reached upon clinical examination, microbiology findings and intraoperative aspects.

IV.4 Diagnosis

Clinical evaluation includes: patient history, physical examination and vascular imaging (arteriography, ultrasonography, contrast-enhanced CT, endoscopy).

IV.5 Therapy

Surgical therapy is mandatory, antibiotic therapy alone not being enough.

General principles of the overall management strategies: Determining the extent of graft infection ± removing the graft; Debridement of the arterial wall and perigraft tissues; Draining and antibiotic therapy.

The therapeutic options are: Graft excision without revascularization; Graft preservation; Excision + EAB [6]; Excision + in-situ replacement [8].

Calligaro and colleagues recommended specific criteria for selective graft preservation:

- patent graft that is not constructed of polyester (Dacron);
- anastomoses are intact and not involved in the infection;
- patient has no clinical signs of sepsis.

Antibiotic prophylaxis protocols for vascular procedures are as follows:

Cefazolin 1-2 g IV slowly prior to induction of anesthesia and repeated (1-2g) each 8 hours for 24-48 hours, or cefuroxime 1.5 g IV and each 12 hours for a total of 6 g; a single dose of cefazolin 1 g IV is recommended prior to endovascular stent implantation;

- When MRSA (methicillin-resistant Staphylococcus aureus) is cultured from body surfaces or is a known important pathogen in hospitalized patients, add vancomycin 1 g IV infused over 1 hour;
- If the patient has a cephalosporin allergy, give aztreonam 1 g IV each 8 hours for 24 hours;
- If the patient has a vancomycin allergy, give clindamycin 900 mg IV over 20-30 minutes followed by 450-900 mg IV each 8 hours for 24 hours.

Coincidental pharmacutical quantitative details

The risk factors for graft infection are:

1. Bacterial contamination of the graft; Faulty sterile technique; Prolonged preoperative stay; Emergency surgery; Extended operative time; Reoperative vascular procedure; Simultaneous gastrointestinal procedure;
2. Remote infection; Postoperative superficial wound infection/skin necrosis/seroma/lymphocele;
3. Allergic host defenses; Bacterial slime producing a protective biofilm;
4. Systemic factors (Malnutrition; Leukopenia/lymphopenia; Malignancy; Corticosteroid administration; Chemotherapy; Diabetes mellitus; Chronic proliferative disorders; Malignancy; Corticosteroid administration; Chemotherapy;
5. Local factors (Biomaterial foreign body reaction; Bacterial slime producing a protective biofilm).

V.2 Prevention

Vascular infections can be minimized if some simple principles are applied:

- avoid a prolonged preoperative stay to minimize the development of skin flora resistant to commonly used antibiotics;
- have patients shower or scrub with an antibacterial soap the night before the operation;
- control the remote infections before an elective operation;
- remove operative site hair immediately before surgery using scissors rather than razors, to minimize skin trauma;
- protect vascular grafts from contact with contaminating sources, especially the exposed adjacent skin, using iodine-impregnated plastic drapes or antibiotic-soaked towels;
- avoid simultaneous gastrointestinal procedures during grafting;
- use prophylactic antibiotics whenever a graft or stent is implanted;
- longer duration of perioperative antibiotics (>48 hours) may be considered whenever patients present more than tworisk factors for wound infection, including extremes of age, malnutrition, chronic illnesses such as diabetes, remote infections or prior irradiation of the surgical site.

In some vascular centers, prophylactic antibiotics are continued for 3 to 5 days in patients being at high risk for infection from bacteremia, prolonged preoperative hospitalization or high institutional wound infection rates (>10%).
Algorithm for evaluation of a suspected prosthetic graft infection [3]

<table>
<thead>
<tr>
<th>Suspected Graft Infection</th>
<th>GEE/GEF (GI Bleeding)</th>
<th>P0/02 Infection (local/systemic infection of autogenous graft)</th>
<th>P1 Infection (non-autogenous graft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Scan/Colonoscopy/EGD</td>
<td>Pos</td>
<td>MRI/CT abdomen/thorax/hip/groin</td>
<td>Pos</td>
</tr>
<tr>
<td>GI Source identified</td>
<td></td>
<td>Scintigraphy</td>
<td>Ultrasound</td>
</tr>
<tr>
<td>Treat</td>
<td>Pos</td>
<td>Arteriogram</td>
<td></td>
</tr>
<tr>
<td>Observe/Surgery</td>
<td></td>
<td>Scintigraphy</td>
<td></td>
</tr>
<tr>
<td>Observe/Surgery</td>
<td></td>
<td>Surgery</td>
<td></td>
</tr>
</tbody>
</table>

Source: Taken from Rutherford Vascular Surgery, sixth edition, chapter 59:879, written by Bandyk DF, Back MR; Infection in prosthetic vascular grafts. Where: GEE, graft-enteric erosion; GEf, graft-enteric fistula; EGD, esopagogastroduodenoscopy; GI, gastrointestinal; Pos, positive; Neg, negative.

Treatment selection criteria for graft infection patients, considering their symptoms and the microbiological findings:

<table>
<thead>
<tr>
<th>Treatment options</th>
<th>Clinical presentation</th>
<th>Microbiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graft preservation [9]</td>
<td>Early infection and no sepsis</td>
<td>All except Pseudomonas</td>
</tr>
<tr>
<td>Excision alone</td>
<td>Graft thrombosis and adequate collaterals</td>
<td>Positive cultures</td>
</tr>
<tr>
<td>In-situ replacement</td>
<td>- autogenous vein</td>
<td>- invasive graft infections without sepsis or GEE/GEF</td>
</tr>
<tr>
<td>- allograft</td>
<td>- invasive graft infections without sepsis and no suitable autogenous conduit</td>
<td></td>
</tr>
<tr>
<td>- Rifampin-bonded graft</td>
<td>- localized biofilm graft infections</td>
<td>- positive cultures</td>
</tr>
<tr>
<td>Excision and ex-situ bypass</td>
<td>- unstable patient with GEE/GEF</td>
<td>- positive cultures</td>
</tr>
<tr>
<td>- simultaneous</td>
<td>- stable patient with aortic infection ± GEE/GEF</td>
<td>- S. epidermidis</td>
</tr>
<tr>
<td>- staged [10]</td>
<td></td>
<td>- no exclusion criteria</td>
</tr>
</tbody>
</table>

Maneuvers associated to graft preservation:
- repeated and aggressive wound debridement in the operating room;
- daily wound dressing change at each 8 hours using dilute povidone-iodine solution (1ml of 1% povidone solution in 1 l saline solution);
- if wound is closed between serial wound debridement, antibiotic (vancomycin, tobramycin) – impregnated methylmethacrylate beds are implanted in the subcutaneous tissue;
- administration of culture-specific antibiotics;

Referring to revascularisation, several RCTs demonstrated a decrease of morbidity and mortality for Staged treatment vs. Traditional graft excision associated to extra-anatomical procedures.

If a monophasic Doppler arterial signal is present at the ankle after graft excision or if arterial systolic pressure is greater than 40 mm Hg at the ankle or forearm, delayed reconstruction is an option because sufficient collaterals are present to maintain limb viability.

In the presence of critical limb ischemia signs, revascularisation shouldn’t be delayed.

In situ replacements using revolutionary materials is probably the future in this field.
Selection criteria for in-situ reconstruction candidates:
- **Clinical criteria** (presentation months or years after graft implantation; no systemic signs of infection: afebrile, normal white blood cells count, sterile blood culture).
- **Anatomic** (inflammation of tissue adjacent to prosthetic graft; perigraft cavity with absence of graft incorporation; weakening of graft-artery anastomosis(pseudoaneurysm);
- **Microbiologic** (perigraft fluid Gram stain: white blood cells, no bacteria; perigraft fluid culture: no growth; graft biofilm culture: coagulase- negative staphylococci(S. Epidermidis)).

Treatment components for these patients are:
- preoperative and perioperative administration of vancomycin- beginning 3 days prior to replacement;
- wide debridement of inflamed perigraft tissue;
- excision of anastomotic sites;
- cleansing/debridement of tissues and retained graft segment with wound irrigation system;
- replace with rifampin-soaked (60 mg/ml) polyester gelatin or collagen-impregnated polyester vascular prosthesis;
- muscle flap coverage of replacement graft segment in groin, if feasible;
- prolonged (6-week) parenteral administration of culture-specific antibiotics.

Prophylactic use of antibiotic impregnated grafts in patients at high infection risk does bring benefits.

We performed 20 graft excisions for infrainguinal infections with:
- removal of the whole graft;
- radical debridement of perigraft tissues;
- closing of the arteriotomies;
- antibiotic administration.

We tried to preserve the grafts in 6 cases of infrainguinal infections [5], using serial debridement in association with antibiotics and muscle flap coverage. Serial approach was used in 20 cases presenting perigraft collections, beginning with the drainage and followed after 2 or 3 days by graft excision and autogenous graft implantation.

We were unable to perform in-situ replacement using Rifampicin-impregnated prostheses, since we had none available.

In patients presenting with well-localised infections affecting only the end of an aorto-femoral graft, we preferred to perform excision of the terminal portion of the graft and, after healing of the tissues surrounding it, extra-anatomical revascularization [7].

**References**