Netherlands
The Journal of Medicine

ORIGINAL ARTICLE

Vascular graft infection in aortoiliac and aortofemoral bypass surgery: clinical presentation, diagnostic strategies and results of surgical treatment

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ABSTRACT

Objectives: Evaluation of the prevalence, diagnostic procedures and clinical outcome of infections of aortoiliac and aortofemoral vascular grafts presented in our centre.
Design: Retrospective study.
Materials: All patients who underwent a surgical aortoiliac or aortofemoral revascularisation between 1991 and 2001.
Methods: Evaluation of several hospital databases.
Results: 32 cases of aortoiliac and aortofemoral vascular graft infection with varied clinical presentation were found. Enteral bleeding was the first clinical manifestation in 31% of the cases, inguinal swelling, wound, or fistula in 59% and fever or sepsis in 6.3%. In 3% the cause was unknown. The vast majority (84.5%) of the infections presented three or more months after surgery (late infections). In cases of enteral bleeding, endoscopy procedures only revealed the diagnosis in 55%. Diagnostic algorithms including an abdominal CT scan appeared to have a sensitivity of 94% for establishing an accurate diagnosis. Remarkably, no specific risk factors for graft infection could be demonstrated. Furthermore, a 30-day survival of 20% or less was observed in early graft infections, whereas late infections managed with extra-anatomical bypasses appeared to have a better survival rate of up to 70%.
Conclusion: Endoscopy in cases of enteral bleeding and CT scanning overall were shown to be very useful for establishing the diagnosis. Clinical outcome and survival after treatment remain poor.

INTRODUCTION

The infection of a vascular graft is a rare complication in bypass procedures with an estimated incidence of 0.5 to 2.5%. However, the mortality and morbidity rates due to this complication are high (25 to 75%).[1,5,6,10] The identification of a graft infection entails a potentially complicated treatment for both the patient and the surgeon. Of all graft infections, those of vascular prostheses in the aortoiliac or femoral region almost always lead to serious life-threatening situations.[2]

It is known that groin infections predominate as the most common site of contamination.[10-14] Aortofemoral grafts have higher infection rates than aortoiliac grafts.[3]

Although graft infections may manifest with clear symptoms (especially the infections of the femoral graft component), the actual diagnosis can be notoriously difficult, due to subtle and nonspecific signs and symptoms. Several studies have evaluated the available diagnostic techniques and have shown that computed tomography (CT scan) is a clinically valuable technique to detect infectious complications with a high sensitivity and specificity.[2,3,4,7,9-11] However, a possible pitfall in using the CT scan is that the absence of substantial perigraft fluid or air collections does not exclude a graft infection. Especially during the postoperative period of 12 weeks an infection cannot be distinguished from a retroperitoneal haematoma.

Although improvement has been made in clinical management of graft infections, current therapeutic options are still accompanied by high morbidity and mortality rates.[2,6,10-12,14] An accurate and timely identification of a graft infection

** A.F.H. Stalenhoef was not involved in the handling and review process of this paper.

is needed to prevent unnecessary intervention or complications because of late intervention.[6,7,14]
To explore the prevalence of graft infections and the results of diagnostic procedures, we evaluated all registered cases of aortoiliac and aortofemoral graft infections in our hospital over the past ten years. We also looked at the outcome of therapeutic management. In all cases we gathered information on the indication for revascularisation and circumstances at the time of implantation, the way in which a graft infection emerged, the diagnostic algorithms used to demonstrate the infection, and the management and outcome.

METHODS

In order to collect all cases we consulted three different databases over the last ten years (from 1991 to 2001): the hospital information system, the database of the infectious disease consultation service and the surgical archives.
In the vascular surgical archives (lists of performed procedures, with indication), search terms were: 'infectious complications' in combination with 'aortoiliac or aortofemoral or aortic vascular graft', 'extra-anatomical bypass', 'aorta' and/or 'vessel infection', 'prosthesis infection', 'axillo-(bi)femoral bypass', 'infected central vessel prosthesis', 'pseudoaneurysm', 'removal of a central vessel prosthesis'. Medical records of these patients were collected and thoroughly studied. The cases in which the aortoiliac or aortofemoral graft was infected were included. Infected 'crossover' prostheses were excluded. The same method was used on the infectious diseases consultation service, in which the diagnosis 'infection of aorta and/or vessel graft' was formulated. In the hospital system we looked for the registered complications (infection) of performed central bypass surgery.
The following data were gathered from the medical records of all included cases: clinical presentation of infection, time between initial bypass surgery and graft infection, indication for bypass surgery, type and place of the infected graft, presence of risk factors for infection (*table 5*), sequence and results of used diagnostic procedures, time between presentation and diagnosis, method of treatment, complications and outcome of treatment and cultured microorganisms on removed grafts. All data was analysed with the help of a database programme.

RESULTS

Prevalence

Between 1991 and 2001, 964 procedures for central blood vessel reconstruction were performed in our Centre. Altogether, 32 cases with an aortoiliac or aortofemoral graft infection were found. Most patients (n=27) emerged after three months or more and were therefore categorised as 'late infections' (84.5%). The initial clinical presentation of late infections could be divided into three groups, 'enteral bleeding', 'malaise/fever' and 'palpable mass', as shown in *table 1*. All cases of 'early graft infection' (presentation within three months after operation) presented with inguinal fistula or wound. In these various presentations, enteral bleeding indicates an aortoenteric fistula, which can be considered as a subset of aortic graft infection. The characteristics of the patients are shown in *table 2* and the different sites of infection are summarised in *table 3*. To evaluate the diagnostic procedures used, as well as the management and outcome of the included cases, we analysed all relevant and available data as provided by the medical records.

Table 1
Clinical presentation of patients (n=32) with infection of aortoiliac or aortofemoral vascular graft

CLINICAL PRESENTATION	NUMBER OF PATIENTS (%)
Early central graft infections	
Inguinal fistula or wound	5 (15.6)
Late infections	
Enteral bleeding	10 (31.3)
Malaise, fever	2 (6.3)
Palpable mass In abdomen (n=3) In the groin (n=4) With fistula/wound in groin (n=7)	14 (43.8)
Unknown*	1 (3.1)

**No data on the initial clinical presentation were available for this patient, who was operated immediately because of an infected aortic graft.*

Diagnostic techniques

The various diagnostic procedures used are presented per group of patients in *table 4*. Cases with 'enteral bleeding' (n=10) were predominantly admitted to the Department of General Internal Medicine. The severity of the bleeding varied from massive (with haemodynamic instability or coma) to minimal blood loss over a longer period. Apart from the one case in which no investigations were carried out because of massive bleeding (immediate operation), endoscopy was the first diagnostic technique used (*table 4*). Only a small blood clot may represent an aortoenteric fistula. However, in some cases the fistula itself or even the prosthesis was observed during endoscopy. Six out of eleven endoscopies revealed a fistula or a visible prosthesis in the enteric tract (sensitivity of 55%). Repeated endoscopy

Table 2
Age, gender, graft position and indication for revascularisation in 31 patients with graft infection

	ESTABLISHED INFECTION				ALL
	LATE INFECTION			EARLY INFECTION	
	ENTERAL BLOOD LOSS	MALAISE, FEVER, WITHOUT OTHER SIGNS	SWELLING IN ABDOMEN OR GROIN		
Men:women	9:1	0:2	11:3	4:1	24:7
Age (mean ±SD)	70	72	68	69	70
Location of prosthesis					
Aorta prosthesis	5	1	0	2	8
Aortoiliac prosthesis	5	1	12	2	20
Iliacoiliac	0	0	2	0	2
Iliacofemoral	0	0	0	1	1
Indication for revascularisation					
Intermittent claudication	4	0	11	1	16
Critical ischaemia	0	0	1	1	2
Aneurysm	5	1	0	2	8
Ruptured aneurysm	1	1	1	1	4
Infected aneurysm	0	0	1	0	1

Table 3
Observed infections

		LATE INFECTIONS	EARLY INFECTIONS
Aortic graft/aortic part of graft	Nonaneurysm	10	0
	Aneurysm	2	0
Iliac part of the graft	Nonaneurysm	13	5
	Aneurysm	2	0

appeared to be useful in eventually finding a fistula or prosthesis in another patient. In the cases in which endoscopy did not reveal the diagnosis, a CT scan was then performed (*table 4*), always after determination of infection parameters (ESR, CRP and/or white blood cell count). The results of three out of the four CT scans performed indicated a graft infection (fluid collection, hypodense tissue and/or gas bubbles surrounding the prosthesis) (sensitivity of 75%). Thus, in more than half of the graft infections presenting with enteral bleeding, the diagnosis could be made within two or three days. The period of time until diagnosis increased in the cases in which an endoscopy did not demonstrate the site of the bleeding.

All cases with inguinal pain, fistula or wound were treated immediately by a vascular surgeon. Infection of the graft was already suspected by evaluation of the medical history. In most cases, taking the body temperature was the first diagnostic investigation, followed by determination of infection parameters and culturing wound smears. As shown in *table 4*, various diagnostic routes were used for establishing the diagnosis. Although in some cases the diagnosis could be made on the basis of physical examination alone, the diagnostic techniques used were primarily related to the clinical presentation (inguinal pain, swelling, a fistula or a wound). In most cases, abdominal or inguinal ultrasound was undertaken to evaluate signs of infection (fluid around the graft or abscess formation, or a pseudoaneurysm in case of swelling). An abdominal CT scan was performed, predominantly to evaluate the extent of the infection. In some cases a diagnostic puncture from a fluid collection or abscess was carried out. Angiographies were performed in cases of swelling of the groin which were suspected of being a pseudoaneurysm (infected or not). All the CT scans (n=9) demonstrated fluid collections, or showed the presence of a (pseudo)aneurysm (sensitivity of 100%). In two of nine patients, the revascularisation procedure had been performed less than three months previously, so the fluid detected by CT scan or ultrasonography may also have been a consequence of the procedure itself. The ultrasound investigations, frequently

Table 4
Diagnostic procedures in individual patients suspected of graft infection

USED DIAGNOSTIC MODALITIES	NUMBER	SENSITIVITY (%)	MEAN TIME PERIOD TO DIAGNOSIS (DAYS)
Internal medicine department			
Enteral bleeding			
Endoscopy only	4	*Duodenoscopy*	1-3
Endoscopy (three times), bleeding scan	1	6 of 11 (54%)	
Endoscopy, coloscopy, CT (one also had a DSA)	3		
Endoscopy, echo, CT	1	*CT scan*	
No diagnostic process (direct operation for massive bleeding)	1	3 of 4 (75%)	
Illness, fever, septicaemia			
US (twice), CT (twice), sigmoidoscopy, coloscopy, IgG scan	1	*CT scan* 2 of 2 (100%)	5-14[1]
CT, leucocyte scan	1		
Surgical department			
Early infection (wound after operation)			
CT	1	*CT scan*	7[2]
Echo, CT, CT-guided puncture	1	3 of 3 (100%)	
CT (twice), leucocyte scan	1		
No diagnostic process	2		
Late infections; inguinal fistula/wound			
US, CT, with: US-guided puncture and leucocyte scan Leucocyte scan CT-guided puncture, IgG scan	 1 1 1	*CT scan* 9 of 9 (100%)[3]	105[4]
US, US-guided puncture, CT	1		
US, angiographic view	1		
US, MRI	1		
CT, fistulogram	1		
CT (three times), IgG scan	1		
Fistulogram (three times), CT	1		
Angiography	1		
No diagnostic process	3		

CT = abdominal computed tomography; US = abdominal ultrasound investigation. [1]CT scan performed on the first day already showed signs of graft infection. [2]Initial blood cultures were taken and antibiotic therapy was started. Additional investigations were performed later. [3]Two CT scans in this group were within three months after the (second) operation and therefore do not indicate infection. Two CT scans were performed because of an initial aneurysm, and not because of suspected infection of a prosthesis. [4]In the outpatient clinic.

preceding the final CT scan, all indicated the presence of fluid or infiltrated (hypodense) tissue around the graft. Fistulograms appeared to be helpful in demonstrating the connections between anatomical structure and the graft. The diagnostic period in this group depended primarily on the clinical presentation. In cases of a local inguinal wound infection after bypass surgery an initial treatment with antibiotics in order to prevent ongoing infection, delayed further investigation.

Most diagnostic effort was made in two cases with 'septicaemia without any indications of a central graft infection'. *Table 4* shows the additional diagnostic algorithms used, after standard blood examination for elevated parameters of infection. In these cases, a CT scan was the first diagnostic technique to evaluate the cause of the fever. Noteworthy, after fluid collections surrounding the graft were detected (which occurred in both cases), even more investigations (white blood cell scan and an IgG scan) were performed to establish convincingly the graft infection and decide on surgical intervention.

In summary, 19 CT scans were performed in the 32 included cases, of which 18 demonstrated a fluid collection or other findings due to an infection (sensitivity of 94.7%). In all other cases the graft infection was demonstrated by

Table 5
Management and outcome in the case of proven graft infection

TREATMENT	COMPLICATIONS	SURVIVAL[1]
Enteral bleeding (n=10)		
Surgery (n=9)	Exsanguination (n=2)	2 (20%)
Graft removal and closure of enteral defect, bypass: Axillobifemoral (n=8) Axillofemoral with crossover (n=1)	Septicaemia, ARDS, MOF (n=4)	
Antibiotics (n=1)[2]		
Inguinal swelling/wound/fistula (n=19)		
Drainage, wound exploration, antibiotics[3], surgery (n=14)	**Early complication (n=5)**	1 (20%)
Graft removal (n=13): whole graft (n=9), part of leg (n=4) Extra-anatomic bypass (not done in 4 cases)[4] Axillobifemoral (n=2) Axillofemoral/poplitial (n=2) Axillofemoral and crossover Veneus/Dacron[5](n=1) Crossover Veneus/Dacron[5] (n=4) Replaced bifurcation (Dacron[5]) with local gentamycin (n=1)	Sepsis, MOF (n=3) Amputation (n=2) **Late complication (n=14)** Thrombosis of the bypass (n=5) Sepsis and MOF (n=1) Injury of serosa followed by reoperation (n=2) Fever (n=2)	10 (71%)[6]
Septicaemia, malaise, without further signs (n=2)		
Surgery (n=2)	Septicaemia, MOF (n=2)	None
Graft removal, extra-anatomic bypass: Axillobifemoral (n=1) Crossover (n=1)		

ARDS = adult onset respiratory distress syndrome, MOF = multiple organ failure. [1]Within 30 days after surgery. [2]Patient refused surgery because of the associated risks, he is still alive and attends the outpatient clinic with persistent episodes of fever. [3]It is not known whether this was done first in all patients; furthermore some of these patients could, unknown to us, have had a later operation in another hospital. [4]E.g. because of lack of possibility for reconstruction. [5]Rifampicine coated. [6]Seven of these patients had persistent fistula or infection of the retroperitoneal remaining part of the prosthesis.

a combination of diagnostic tests, including white blood cell scans (n=4) and IgG scans (n=3) showing hotspots in the graft region. Of these other tests the endoscopy and ultrasound techniques were useful specifically in subsets of patients.

Management and outcome

As shown in *table 5*, nearly all cases of enteral bleeding underwent surgery to remove the infected graft. To maintain circulation an extra-anatomic bypass was made. In the two cases of septicaemia without further clinical clues, the same procedure was carried out. The overall survival rate in this group was poor and serious complications occurred (*table 5*).

Patients who presented with a local wound or fistula in the groin were usually first treated by drainage and removal of infected tissue, followed by antibiotics. After a period of time (weeks or months) the removal of the graft was necessary. Patients with an aneurysm were operated in order to treat the aneurysm and to evaluate the graft for infection. Frequently, only a part of the prosthesis was removed and replaced by a rifampicin-coated substitute graft. Furthermore, gentamicin-containing beads were left behind in more than half of the cases, in order to get prolonged local antimicrobial activity. Survival in this group of patients appeared to be better (71% of the patients with an inguinal infected graft (i.e. the late infections) survived). However, a prolonged complication rate was seen in this group (*table 5*). The five patients with an early graft infection (less than three months after implantation) showed a survival rate of only 20%. Culturing of the removed graft revealed predominantly *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Pseudomonas* and *Enterococci species*.

Predisposing factors

In the 32 cases of aortoiliac en aortofemoral graft infection (*table 6*), none of the supposed risk factors we checked for were present in more than 35% of the patients. Surprisingly, only two out of the 32 patients with a graft infection had diabetes. In our group, five of 32 patients underwent reoperation at the infection site, which can be noted as an acquired risk factor.

DISCUSSION

This retrospective descriptive study confirms that although the prevalence of central graft infection is low, it is associated with a high morbidity and mortality rate, in this case series of up to 80%. Furthermore, in case of enteral

Table 6
Factors associated with graft infection

	AT RISK (N)	NOT AT RISK (N)	PERCENTAGE	UNKNOWN
Preoperative risk factors				
Length of hospital stay before surgery	7	16	30	9
No perioperative antibiotics given	0	16	0	16
Peroperative risk factors				
Acute surgery within 24 hours	5	27	16	0
Other interventions during surgery[1]	4	23	15	5
Duration of surgery (>3.5 hours)	4	15	21	13
Complication during surgery[2]	8	18	31	6
Body mass index >25 kg/m^2	4	14	22	14
Postoperative risk factors				
Complications[3]	10	16	38	6
Intensive care >5 days	5	18	22	9
Postoperative wound infection	8	18	31	6
Other risk factors				
Diabetes mellitus	2	30	6	0
Low resistance to infection[4]	9	21	12.5-30	0
Illness just before the emerging infection	6	26	19	0
Surgery just before the emerging infection	11	21	34	0

[1]Embolectomy (twice), profunda replacement (once), replacement of a bifurcation prosthesis instead of an aortic prosthesis placed in the same procedure. [2]Bloodloss (six times), injury of serosa (twice). [3]Thrombosis (twice), bleeding (twice), necrosis of sigmoid, ARDS (twice), metabolic acidosis (once), inguinal abscess (twice). [4]Use of prednisone, recent radiotherapy, paraproteinaemia, malignancy in recent past.

bleeding and wounds or swelling in the groin, the diagnosis can be made rapidly with endoscopy and CT scan, and this may prevent an extensive diagnostic process, including an invasive guided puncture for culturing.

Although the clinical presentation of graft infection shown in our study is well known from previous studies,[8,10,11-14] the fact that most patients were diagnosed within two days is remarkable and not been mentioned in other studies. The large number of patients presenting with enteral bleeding may explain this, because in these cases a gastroscopy and a CT scan were carried out on the same day, confirming the diagnosis. This vigorous diagnostic process was also observed in patients who presented with an inguinal fistula or spontaneous wound in the groin.

This retrospective study also clearly demonstrates the great diagnostic sensitivity of computed tomography (94%) in other patients with less clear clinical symptoms, comparable with the observations of Orton *et al.*[5] and Low *et al.*[9] Modral and Clagett also advocated the CT scan in diagnosing late aortic graft infections.[1] They recommend duplex ultrasonography in cases of superficial grafts to show perivascular fluid or pseudoaneurysms. The results of our study are similar to these observations. However, this outcome should be interpreted with caution, because of the retrospective character of these studies, with exclusive inclusion of established infections. Patients with an actual graft infection that could not be determined by the diagnostic methods used may have been lost to follow-up, may have died without the exact diagnosis being established or may have been treated for another supposed diagnosis.

The sequence of the variable diagnostic methods used in our patients is comparable with reported algorithms[5] and proves to be practical and appropriate for this diagnosis. Our study does not provide evidence for the necessity of nuclear IgG or bleeding scans in those cases in which a CT scan has already demonstrated a graft infection.[6]

Our study confirms the statement by Orton *et al.*[5] that in patients with upper or lower gastrointestinal bleeding after an aortic graft, a graft to intestine fistula should be excluded by endoscopy. In our series this technique demonstrated a fistula in 55% of the cases, but could at the same time exclude other causes of the bleeding.

The group of patients who were suspected of having a graft infection but not confirmed after diagnostic investigations was too small to draw conclusions about the specificity of the various diagnostic methods. Moreover, it should be taken into consideration that negative cultures of removed grafts may not fully exclude graft infection, since undetectable micro-organisms may be present.

The cultured micro-organisms of removed grafts in our

study are largely comparable with those observed by others.[3,10,11] Bunts *et al.* observed *Staphylococcus aureus* in 43%, *E. coli* in 17%, *Staphylococcus epidermidis* in 14% and *Pseudomonas* in 10% of the cases of graft infections. More recent studies show similar bacterial infections, although coagulase negative *Staphylococcus epidermidis* has now been emphasised as an important cause of aortic graft infections rather than an innocent bystander.

The survival rates observed in our study should be considered with caution, because we only have follow-up data on patients who did not survive and not on those who may still be alive. Moreover, the overall prevalence of infectious complications may be underestimated if not all the graft infections were referred to our hospital.

Our study did not clarify the possible role of risk factors in the development of graft infection. It is known that graft infection may occur haematogenously or per continuum from surrounding tissue.[10] Some theories suppose that micro-organisms may dwell on the graft from the time of implantation and multiply when the condition of the patient deteriorates. Orton *et al.* state that largely sterile abdominal aortic aneurysms yield positive cultures of the intraluminal clot in 8 to 20% of the cases, but despite this, graft infection does not usually occur.[5] Various graft materials have been studied in an attempt to further prevent infections due to vascular surgery. Graft-to-intestine fistulas may be prevented by closing the aneurysmal aortic wall remnant and the peritoneum over the newly inserted graft. However, this procedure is routinely performed in abdominal aneurysm reconstruction, not in bypass surgery. Other well-accepted risk factors are emergency operations, faulty sterile technique, prolonged preoperative hospital stay, extended operation time and reoperation at the site of infection.[10] The fact that no special risk factors were evident in our study does not mean that these factors do not play a role in the developing of a graft infection. Also, the lack of a control group makes it difficult to estimate the influence of such a factor.

Based on the results of this retrospective study, the best ways of dealing with a patient suspected of having an infected aortoiliac or aortofemoral graft are endoscopy in cases of enteral bleeding and CT scanning in all other cases. Both were shown to be very useful techniques for establishing the diagnosis. In general, the clinical outcome and survival after treatment are still poor. To further evaluate the exact merit of various diagnostic procedures and the role of possible risk factors, prospective studies on a larger scale should be performed.

ACKNOWLEDGEMENT

We are grateful to Dr. F.G. Buskens, vascular surgeon, for allowing us to evaluate parts of his well documented operation records.

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