

Hematogenous infection after knee arthroplasty

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Twenty-five hematogenously infected knee arthroplasties in 20 patients (17 with rheumatoid arthritis and 3 with arthrosis) were followed for 3 years. *Staphylococcus aureus* was the major infecting organism. Three patients with four arthroplasties died of sepsis. Two patients had removal of the arthroplasty, one of which resulted in an above-the-knee amputation. Four out of five arthrodeses fused. Two knees healed after early debridement and two healed without surgery. Ten knees had successful revision arthroplasty.

Rheumatoid arthritis and constrained prostheses increase the risk of hematogenous infection. Any infection and especially cutaneous lesions in a patient with a knee arthroplasty should be treated vigorously.

The overall incidence of postoperative infection after knee arthroplasty has been reduced from about 10 per cent to less than 2 per cent because of changes in perioperative routines and choice of prostheses during the last decade (Knutson et al. 1986, Bauer et al. 1987). However, hematogenous infection following knee arthroplasty is an uncommon but constant menace to the patient.

We report a follow-up of 25 hematogenously infected knee arthroplasties.

Patients and methods

The cases (Table 1) were collected from nine hospitals in Sweden. Information was accumulated by chart review.

Twenty patients (25 knees) qualified for the study by meeting the following criteria of hematogenous infection:

1. Wound healing per primam of the index arthroplasty with no signs of infection for 1 year.
2. Decrease of ESR during the first postoperative year to not more than 10 mm/h above the preoperative level.

3. Local signs of infection of the prosthetic joint.
4. Growth of the same bacteria in two or more knee aspirations, and/or three or more positive cultures from five tissue biopsies taken at the time of revision operation.

Furthermore, attempts were made to isolate bacteria in the blood and at the distant site.

The arthroplasties had been performed between 1973 and 1981. There were 14 women and 6 men with a median age of 63 (44-73) years. The underlying diagnosis was rheumatoid arthritis in 17 patients and arthrosis in 3. The prosthesis used was hinged or stabilized in 14 knees, bi- or tricompartmental in six and unicompartamental in five. Eight patients had had previous knee surgery including three synovectomies, three tibial osteotomies, and four arthroplasties (three failed owing to mechanical loosening; one - Case 7 - failed due to infection by *Staphylococcus epidermidis*, discovered postoperatively by growth in tissue biopsy cultures taken intraoperatively, the revision being performed for mechanical loosening. Gentamicin cement was used and peroral antibiotics continued for 6 months. The prosthesis functioned well and there were no signs of infection for 5 years. Twelve patients had contralateral knee arthroplasties and 3 patients had four total hip replacements; five of the contralateral knee arthroplasties became infected.

The median interval between index arthro-

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Table 1. Case reports of 20 patients with hematogenously infected knee arthroplasty

Case	Age ^A / Sex	Diagnosis ^B	Index arthro- plasty ^C	Asymptomatic interval (mo)	Infecting organism ^D	Distant focus	Treatment ^E	Follow-up (mo)	Outcome [*]
1	53/F	R	At	22	Sa+bSB	Foot ulcer	Arthrodesis ¹⁺²	11	Fused.
2	57/F	R	At	44	Sa	Foot ulcer	Arthrodesis ¹⁺²	64	Fused. (Figure 1)
3	49/M	R	Gp	54	bS?	Leg ulcer	None	0	Dead after 1 week in sepsis.
4	67/M	R	Ma	22	Cp	Abdominal surg	None	0	Dead after 1 week in sepsis.
5	66/M	R	Gp	36	Cp	Abdominal surg	None	0	Dead after 1 week in sepsis.
6	63/M	R	At	19	Sa	Urinary tract	Antibiotics	55	Functioning prost- hesis.*
7	66/F	R	TC	57	Sa	Foot ulcer	Revision-PCA ¹	34	Functioning prost- hesis.*
8	63/F	R	Ma	84	Sa	Foot ulcer	Revision-PCA ¹	34	Functioning prost- hesis.*
9	56/F	R	Gp	18	Sa, Pv, Pm	Unknown	Resection ar- throplasty	141	Reinfection. Above- knee amputation.
10	57/F	R	At	24	bSG	Foot ulcer	Debridement	88	Salvaged.
11	73/F	R	Gp	111	Sa	Unknown	Resection ar- throplasty	42	Healed.
12	65/F	R	Ma	23	Sa	Upper resp tract	Revision-Sp	87	Functioning prost- hesis.*
13	44/M	R	Gp	44	Sa	Infected op wound	Debridement	65	Reinfected. Revis- ion-Sp. Funct. prosth.
14	63/F	R	ICLH	34	Sa	Urinary tract	Revision-ICLH ¹	30	Functioning prost- hesis.*
15	65/F	R	ICLH	12	Sa	Urinary tract	Revision-ICLH ¹	30	Functioning prost- hesis.*
16	69/F	R	Wa	45	Sa	Lower resp tract	Revision-Sp	20	Functioning prost- hesis.*
17	69/F	R	Wa	45	Sa	Lower resp tract	Antibiotics	20	Functioning prost- hesis.*
18	55/F	R	Gp	16	Sa	Infected op wound	Debridement	110	Functioning prost- hesis.*
19	54/M	A	Ma	39	Sa	Leg ulcer	Revision-Ki ¹	74	Functioning prosthesis.
20	64/F	A	Tw	22	Sa	Leg ulcer	Arthrodesis ³	106	Fused.
21	66/F	A	Gp	36	Sa	Upper resp tract	Arthrodesis ³	38	Not fused.
22	67/F	A	Tw	24	Sa	Upper resp tract	Revision-At ¹	38	Functioning prost- hesis.
23	58/F	R	SG	13	Sa	Foot ulcer	Debridement	95	Reinfected. Arth- rodesis ³ Fused.*
24	68/M	R	Gp	16	Sa	Urinary tract	Arthrodesis ³	0	Dead 2 days postop in sepsis.
25	57/F	R	Ma	17	Se	Infected op wound hesis	Revision-ICLH ¹	100	Functioning prost-

| Patient with bilateral infected knee arthroplasties.

A Age at arthroplasty.

B A arthrosis, R rheumatoid arthritis.

C At Attenborough, Gp Guepar, ICLH Imperial college, London Hospital, Ki Kinematic, Ma marmor, PCA Porous Coated anatomic, SG S:t Georg, Sp Spherocentric, TC Total Condylar, Tw Townley, Wa Walldius.

D Sa *Staph.aureus*, Se *Staph.epidermidis*, bSB beta-streptococcus group B, BS? unspecified beta-streptococcus, bSG beta-streptococcus group G, Pm *P.morganii*, Pv *P.vulgaris*, Cp *Clostridium perfringens*.

E 1 Two-stage procedure using gentamicin beads (septopal®).

2 Intramedullary nailing using a long Kuntscher nail

3 External fixation (Charnley, Hoffmann).

Ongoing antibiotics

plasty and onset of infection was 2 (1–10) years. Median follow-up from onset of infection was 3 (0–8) years.

Results

Three patients with four infected knee arthroplasties died of sepsis. Two patients had removal of the prosthesis, one of which resulted in an above-the-knee amputation. Two knees healed after early debridement and two healed without surgery. Four of six arthrodeses healed; one of the nonfused arthrodeses was in a patient who died of sepsis within a week. Ten knees had successful revision arthroplasty.

A positive culture was obtained by repeated aspirations in 24 knees and by an intraoperative biopsy in one (Table 2). In 11 cases the joint pathogen was also cultured at the distant focus and in 3 of these cases also in the blood. In 18 patients a distant focus of infection was identified (Table 3).

The median interval between onset of infection and final treatment was 4 (0–40) weeks.

In 9 cases (Cases 7, 8, 12, 15, 21–25) radiographic loosening of the prosthesis was found, i.e., a complete radiolucent zone more than 2-mm wide around the components. In all the other cases the zones were less than 2-mm wide and only around parts of the components.

Table 2. Bacteriology in hematogenously infected knee arthroplasties in previous reports and in the present study

Pathogens	Previous reports	Present study
<i>S. aureus</i>	20+1 ^a	18+2 ^a
β-hemolytic streptococcus	6	2+1 ^a
α-hemolytic streptococcus	1	–
<i>E. coli</i>	7+2 ^a	–
<i>P. multocida</i>	4	–
<i>S. epidermidis</i>	2	1
<i>Clostridium perfringens</i>	–	2
<i>Enterococcus</i>	1+1 ^a	–
<i>Bacteroides fragilis</i>	1	–
<i>Proteus</i>	1 ^a	2 ^a
<i>Pseudomonas</i>	1	–
<i>Moraxella</i>	1	–
<i>Enterobacter aerogenes</i>	1	–
<i>Listeria monocytogenes</i>	1	–

^a In mixed cultures.

Previous reports. Hall 1974, Brand 1974, D'Ambrosia et al. 1976, Burton & Schurman 1977, Arvan & Goldberg 1978, Ahlberg et al. 1978, Marmor & Berkus 1978, Goldberg & Henderson 1980, Wigren et al. 1980, Stinchfield et al. 1980, Thomas et al. 1983, Poss et al. 1984, Bliss & McBride 1985, Grogan et al. 1986.

Nine patients (Cases 1–11) had been operated on in Lund. All of them had rheumatoid arthritis. The incidence was 8 per cent (5/64) for hematogenous infection following Guepar prostheses and 4 per cent (4/98) following Attenborough prostheses. There were no hematogenous infections following nonconstrained prostheses in rheumatoid arthritis (0/169 prostheses) between 1973 and 1981 (constrained versus nonconstrained; $P < 0.002$, Fisher's exact test). During the same period, 339 knee arthroplasties (constrained and nonconstrained) were performed in patients with arthrosis in Lund, and there were no hematogenous infections ($P < 0.002$, Fisher's exact test).

Fourteen cases with infected hinged or stabilized prostheses resulted in three deaths, one above-the-knee amputation, one resection arthroplasty, three arthrodeses (one of which did not fuse), two successful revision arthroplasties, and four prosthesis salvages using early debridement and/or antibiotics. Five cases with infected tricompartmental prostheses resulted in four successful revision arthroplasties and one fused arthrodesis. Six cases with infected unicompartamental prostheses resulted in one death (this patient also had an infected hinged prosthesis in his contralateral knee), four successful revision arthroplasties and one fused arthrodesis.

Case 2. A 61-year-old woman with rheumatoid arthritis had an Attenborough arthroplasty performed on her left knee in 1978. The prosthesis functioned well. In March 1982, she developed an ulcer under her right foot with growth of *Staph. aureus*, and the following month she had a septic arthritis of her left knee, where repeated aspirations showed growth of *Staph. aureus*. In May 1982, the prosthesis was removed and gentamicin beads were inserted. Eight weeks later, when the wound was well healed, the knee joint was fused using an intramedullary nail. At follow-up 5 years later, the arthrodesis had healed and there had been no signs of infection.

Discussion

Up to 1986, there were reports on 48 knees (41 patients) with hematogenous infection after knee arthroplasty; 16 of these had undergone successful salvage procedures (Table 4). The major patho-

Table 3. Distant infectious foci of hematogenously infected knee arthroplasties in previous reports and in the present study

Pathogens	Previous reports	Present study
Cutaneous origin	16	12
Urinary tract	7	4
Respiratory tract	5	5
Oral cavity	5	-
Gall bladder	2	-
Gastrointestinal tract	2	2
Septic arthritis	2	-
Abdominal abscess	1	-
After gynecologic procedure	1	-
Unknown	6	2

See Table 2 for references to previous reports.

gen was *Staph. aureus*, which corresponds well with the bacteriology of our material (Table 2), as well as with that of hematogenously infected total hip arthroplasties as reported by Blomgren (1981).

Our study confirmed previous reports (Table 3) that a cutaneous lesion was the most common source of infection. This stands in contrast to what was found in hematogenous infections of total hips, where dermal foci represented 16 per cent (Blomgren 1981).

Grogan et al. (1986) reported that hematogenous infection seems to be more common in rheumatoid arthritis; out of 604 patients with total knee arthroplasty, 259 had either classical rheumatoid arthritis or related diseases, and eight of 14 infected knee arthroplasties occurred in rheumatoid patients. Rheumatoid patients in our material had a substantially higher risk of contracting hematogenous infection as compared with patients with arthrosis.

The incidence of postoperative infection has been shown to be as high as 12 per cent in hinged prostheses after an average of 3 years (Hui & Fitzgerald 1980) compared with 1 per cent after 3 to 5 years in nonconstrained prostheses (Insall

et al. 1979). Our study clearly showed an increased incidence of hematogenous infection for constrained prostheses in rheumatoid arthritis that might be caused by a combination of factors, such as a larger foreign body, a rigid construction with high interface stress causing a higher incidence of loosening (Deburge et al. 1979) with an increased inflammatory granulation tissue at the bone-cement interface (Willert et al. 1974).

Hematogenous infection after knee arthroplasty can be extremely dangerous for the patient. D'Ambrosia et al. (1976) reported that 2 of 36 patients died of sepsis where β -hemolytic *Streptococcus* group A and *Staph. aureus* were the infecting organisms. Three of our patients died of sepsis because of an infection by *Staph. aureus*, *Clostridium perfringens*, and unspecified β -hemolytic streptococci.

The prophylactic use of antibiotics to cover surgical and dental treatment and intercurrent infections has been advocated by several authors (Hall 1974, Marmor et al. 1978, Stinchfield et al. 1980, Wigren et al. 1980, Brause 1982, Poss et al. 1984). Ainscow & Denham (1984) investigated the risk of hematogenous infection in 1,112 total hip and knee replacements followed for an average of 6 years. They concluded that transient bacteremia from surgical or dental procedures is not likely to infect a replaced joint in otherwise healthy patients, whereas an infected skin lesion producing relapsing bacteremia carries a high risk of joint prosthetic infection especially in patients with rheumatoid arthritis as exemplified by Case 2.

Hematogenous infection after knee arthroplasty is a serious threat. Rheumatoid arthritis and constrained prostheses increase the risk of infection. Any infection and especially cutaneous lesions in a patient with a knee arthroplasty should be treated vigorously.

Table 4. Hematogenously infected knee arthroplasty in previous reports

Author (S)	A	B	C	D	Distant focus	Surg ^E	F	Outcome ^E
Hall 1974	R	MK	66	Ec	Urinary tract	DEB.	26	Sal. sinus
Brand 1975	R	Wa	64	Sa	Gluteal abscess	ART	?	?
D'Ambrosia et al. 1976	R	Wa	25	Sa	Urinary tract or	DEB.	3	Death of septicemia
	R	Wa	24	Sa	Decubital ulcer	DEB.	3	Death of septicemia
	R	Gm	14	bSA	Postop. following	—	1w	Death of septicemia
	R	?	17	bSA	hand surgery	—	1w	Death of septicemia
Burton & Schurman 1977	R	Gp	19	Sa	Acute osteomyelitis	DEB.	11	Sal. pain on weight-bearing
	R	Gp	18	Sa	of the jaw	DEB.	11	Sal. sinus
Arwan & Goldberg 1978	O	FS	4	Pm	Cat bite	DEB.	17	Sal.
Ahlberg et al. 1978	R	Gm	16	bSB	?	DEB.	4	Sal.
Marmor & Berkus 1978	R	Ma	6	Ps	Op. wound infection	ART.		Fused
	R	Ma	11	Ec	Cholecystitis	ART.		Fused
	O	Ma	9	Ec	Cholecystitis	REV.		Reinfected ART. fused?
	R	Ma	8	Sa	Septic arthritis	REV.		Reinfected ART. fused
Goldberg & Henderson 1980	R	IC	38	Pm	Cat bite	DEB.	45	Sal.
	R	IC	40	Ec	After cystoscopy	DEB.	32	Sal.
	O	IC	21	Ec	Abdominal abscess	DEB.	49	Sal.
	O	IC	16	Ec	After gyn procedure	DEB.	49	Sal.
Poss et al. 1984	?	?	41	Ec+Sa	Urinary tract	?	?	?
	?	?	39	Sa	Skin lesion	?	?	?
	?	?	60	Sa	Gingivitis	?	?	?
Widgren et al. 1980	R	Gc	18	Sa	Pneumonia	REM.	42	Healed
	R	Gc	18	Sa	Pneumonia	REM.	42	Healed
	R	Wa	48	Sa	Pneumonia	DEB.	17	Sal.
	R	Wa	48	Sa	Pneumonia	DEB.	17	Reinfected. REV. healed
Stinchfield et al. 1980	R		48	Bf	G-I tract	ART.		Fused
	R		26	Se	Thigh skin graft	DEB.		Reinfected. ART. fused
	R		5	bSG	Dental abscess	DEB.		Sal.
	R		16	Sa	Cellulitis of foot	DEB.		Reinfected. ART. fused
	R		16	Pm	Foot ulcer	DEB.		Sal.
Thomas et al. 1983	R		26	Sa	Toe infection	DEB.		REM. Healed?
	R		20	Sa	Toe infection	DEB.		REM. Healed?
Bliss & Mc Bride 1985	O			bSB	?	DEB.		Sal.
	O			Sa	?	DEB.		Sal.
	O			bS-D	Pneumonia	REV.		Healed
	R		51	Pm	Cat scratch	DEB.		Sal.
	R			Sa	Foot ulcer	REV.		Healed
	O			Ec	Urinary infection	ART.		Fused
	O			Pr+EN	Urinary infection	ART.		Reinfected
	O			Sa	Colocutaneous fistula	DEB.		Reinfected
	R			Se	?	DEB.		Reinfected
O			Sa	Stasis ulcer	REV.		Healed	
Grogan et al. 1986	R	Gp	19	Ec+En	Urinary infection	ART.	47	Fused
	SI	TC	4	Mx	?	DEB.	28	Sal.
	SI	TC	14	Sv	Dental procedure	DEB.	18	Sal.
	JR	Gp	4	Ea	Urinary infection	ART	76	Fused
	R	TC	18	Lm	?	DEB.	26	Sal.
R	TC	40	Sa	Septic arthritis	DEB.	24	Reinfected. ART. fused	

A Diagnosis, JR Juvenile rheumatoid arthritis, O Osteoarthritis, R Rheumatoid arthritis, SL Systemic lupus erythematosus.
 B Arthroplasty, FS Freeman-Swanson, Gc Geometric, Gm Geomedic, Gp Guepar, Ic ICLH, Ma Marmor, MK McKee hinged, TC Total condylar, Wa Walldius
 C Asymptomatic interval in months
 D Pathogen Bf Bacteroides fragilis, bSA, bSB, bS-D, bSG streptococci, group A, B, non-group D, Group G, Ea Enterobacter aerogenes, Ec E coli, En Enterococcus, Lm Listeria monocytogenes, Mx Moraxella, Pm Pasteurella multocida, Pr Proteus, Ps Pseudomonas, Sa Staph aureus, Se Staph epidermidis, Sv Streptococcus viridans
 E DEB Debridement, ART Arthrodesis, REM Removal of prosthesis, REV Revision arthroplasty, Sal. Salvaged
 F Follow-up in months, w week

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