DEEP INFECTION IN CHARNLEY LOW-FRICTION ARTHROPLASTY COMPARISON OF PLAIN AND GENTAMICIN-LOADED CEMENT

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A retrospective review of 1542 Charnley low-friction arthroplasties was carried out to compare the incidence of deep infection arising after plain and gentamicin-containing acrylic cement. There was no significant difference between the two series in primary operations, the infection rate being 1.72% and 1.65% respectively. However, in secondary operations (conversions and revisions) the gentamicin-containing cement gave significantly better results – a 0.81% infection rate as compared with 3.46%. All operations were performed in a clean air enclosure using total-body exhaust suits.

Radiological diagnosis of deep infection was possible within one year of operation in all cases. Late haematogenous infection occurred in one case and was related to a skin lesion.

Deep infection in total hip arthroplasty is a serious problem. Efforts have been made to prevent it, to treat it and to identify the patients at risk.

Until the introduction of the clean air enclosure the infection rate of Charnley low-friction arthroplasties at Wrightington was close to 8% (Charnley 1979). With its introduction the rate was gradually reduced, but not until the number of air changes had reached 300 per hour. This, plus the total-body exhaust suits, have reduced the deep infection rates to below 1%, without the use of prophylactic antibiotics.

In order to study how to reduce the infection rate still further, either large numbers of patients have to be reviewed or attempts made to identify patients at risk. The first would demand multicentre studies – with all the difficulties of ensuring that the environment, the surgical technique, the follow-up and the method of diagnosing infection were uniform. The second, the identification of risk factors, some of which have already been established (Wroblewski and del Sel 1980; Menon and Wroblewski 1983; Menon, Thjellesen and Wroblewski 1983), would have to rely on conclusions drawn from a relatively small

group of patients, so that a single case might affect the overall result.

The results of methods used in the prevention of sepsis, i.e. a clean air enclosure, systemic antibiotics and antibiotic-loaded acrylic cement, have already been reported. The Medical Research Council (MRC) trial reported a multicentre series of 8000 hip and knee replacement procedures. When operations were performed in an ultraclean air environment, as opposed to conventional operating theatres, the incidence of deep sepsis was reduced from 3.4% to 1.6%. When exhaust-ventilated body suits were worn in addition, the rate fell to 0.9% (Lidwell et al. 1982).

The results of parenteral administration of broad-spectrum antibiotics was assessed only by retrospective examination of the MRC data, but it seemed to show that antibiotics plus clean air reduced the deep sepsis rate to 0.7% and that the addition of body exhaust suits further cut the rate to 0.06% (1 case in 1584 operations).

Another method of preventing deep infection is the use of gentamicin-containing bone cement, described by Buchholz and Engelbrecht in 1970. These authors reported an infection rate of 5% of 1161 total hip replacements using plain cement and no parenteral antibiotics; when gentamicin cement was used, the infection rate was reduced to 0.8% of 2399 patients (Buchholz et al. 1977). As the follow-up was lengthened so the infection rate increased, despite the continuing use of the antibiotic-loaded acrylic cement (Buchholz, Elson and Heinert 1984).

Other workers have quoted infection rates of between 2.7% and 10.4% for plain cement, and 0.2% and

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1.2% for gentamicin cement (Thierse 1978; Röttger et al. 1979; Wannske and Tscherne 1979). Josefsson, Lindberg and Wiklander (1981) compared the efficacy of gentamicin cement alone with that of plain cement and parenteral antibiotics in 1685 hip replacements. The results suggested that antibiotic-loaded acrylic cement was a more effective measure against deep infection than parenteral antibiotics and plain cement. The former group had an infection rate of 0.4% and the latter a rate of 1.6%. In their study, the large number of cases included several variables: patients were drawn from 11 surgical centres, seven different types of prosthesis were used and five different types of parenteral antibiotics administered. In some centres, facilities were not available for the culture of anaerobic organisms (Josefsson et al. 1981).

The criteria used to diagnose deep sepsis may affect the final percentage rates. Some series have diagnosed infection only when re-operation is needed. This, coupled with average follow-up times of not more than two years, may lead to artificially low infection rates being reported. We feel that every case should have radiographic scrutiny to prevent so-called "latent" infection being overlooked. This point is highlighted by the authors of the MRC trial who have subsequently stated that further cases of deep sepsis have arisen in patients who had not come to re-operation at the time the report was compiled. If these cases had been suspected of harbouring latent infection then, according to the authors of the trial, the infection rates could have been doubled (Lidwell et al. 1983).

The purpose of this publication is to present, by retrospective review, the incidence of deep infection in two series of patients, comparing the results of plain bone cement (CMW) and those of antibiotic-loaded acrylic cement (Palacos with gentamicin), as used in the Charnley low-friction arthroplasty.

MATERIALS AND METHODS

All patients undergoing Charnley low-friction arthroplasty in the eight-year period from 1976 to 1983 were included in the study. The minimum follow-up was two years.

All the operations were carried out by one surgeon (BMW) using a clean air enclosure and a total-body exhaust suit. Trochanteric osteotomy was used routinely, although the method of reattachment varied slightly over the years. There were also minor changes in the design of components. Prophylactic systemic antibiotics were not used. Cementation techniques did not vary: both acetabular and femoral cement was inserted and compressed using digital pressure; flanged cups were used in an attempt to improve acetabular cement compression. In the first four years CMW cement was used, while in the second period it was Palacos with gentamicin (0.5 g per 40 g pack).

The records were scrutinised for any evidence that might suggest deep sepsis. In each case, the postoperative radiographs were compared with the follow-up radiographs. The features regarded as indicating deep infection were periostitis, endosteal cavitation or increasing demarcation of the bone-cement junction.

All patients coming to revision were operated upon by the one surgeon (BMW), who detailed the operative findings and recorded whether or not he considered that the hip was infected. Bacteriological specimens were taken routinely at revision.

RESULTS

During the eight-year period, 1755 operations were carried out but 178 were operations for known sepsis and were excluded from this study. By the time of review, 35 patients had died, 21 of them within one month of operation and 14 between one month and one year.

Thus, 1542 cases remained for analysis. There were 871 operations in the CMW series and 671 in the Palacos with gentamicin series. The results, subdivided into diagnostic groups, are presented in Table I. The average follow-up for the CMW series was 8.1 years, and for Palacos with gentamicin 3.6 years.

Group 1. Primary operations for osteoarthritis. The percentage infection rates for the plain cement and gentamicin cement in this group of patients were 1.5% and 1.52% respectively, showing that the addition of antibiotic did not reduce the infection rate below that obtained with the clean air enclosure and total-body exhaust suits.

Group 2. Primary operations for rheumatoid arthritis. The infection rate in rheumatoid patients was not statistically different between the two series, but the numbers are relatively small.

Group 3. Operations after previous hip surgery other than total hip replacement or an upper femoral prosthesis. The gentamicin cement cases had a significantly lower rate of infection than the plain cement cases in this previously operated group of patients: 1.82% as opposed to 4%. The majority of these cases required the removal of metallic implants during the same operation.

Group 4. Operations after previous total hip arthroplasty or upper femoral prosthesis. An even more striking difference was seen in this group between the infection rates for plain and gentamicin cement; 2.83% deep sepsis rate was recorded for plain cement, and 0.52% for gentamicin cement. The 2.83% represents three cases infected out of a total of 106, whereas the 0.52% represents only one case out of 192.

The cases of deep sepsis are analysed in Tables II and III. In two cases from the CMW series (Cases 7 and 12) there were no obvious factors operating which might have led to an increased risk of deep sepsis. Both were uncomplicated operations performed for osteoarthritis. There was no case of a similar nature from the

Table I. Results

Group	Diagnosis	CMW plain cement				Palacos + 0.5 g gentamicin			
		Total	Infection		Follow-up (years)	Total	Infection		Follow-up (years)
			Number	per cent			Number	per cent	
All cases		871	19	2.18		671	9	1.34	
1	Osteoarthritis, no previous surgery	599	9	1.50	7.6	395	6	1.52	3.18
2	Rheumatoid arthritis, no previous surgery	41	2	4.88	7.61	29	1	3.45	2.56
3	All diagnoses. Previous hip surgery other than THA or upper femoral prosthesis	125	5	4.0	9.19	55	1	1.82	3.54
4	All diagnoses. Previous THA or upper femoral prosthesis	106	3	2.83	7.76	192	1	0.52	3.07
1 & 2	All diagnoses. No previous hip surgery	640	11	1.72	7.6	424	7	1.65	2.94
3 & 4	All diagnoses. Previous hip surgery or upper femoral prosthesis	231	8	3.46	8.54	247	2	0.81	3.18

THA, total hip arthroplasty

gentamicin series. The remaining 26 cases had factors recorded in the case notes which might have contributed to deep infection.

DISCUSSION

The proportion of deep infections after hip replacement varies considerably in the literature. Factors influencing the figures are the period of follow-up and the criteria used to define infection.

Allegedly, latent infection differs from haematogenous infection in that the organisms in the former are introduced at the time of operation. The low virulence of many of these organisms results in delay of onset of clinical and radiological signs. Murray (1973) found 30% of positive bacterial cultures from operative wound material even when the procedures were performed in a clean air environment. Some authors have suggested that wound infection becomes apparent when infecting bacteria number 10^5 per gram of tissue (American College of Surgeons 1976). The presence of a large foreign body reduces defence and may be the reason that low-virulence organisms infect prostheses. Blomgren (1981) infected prostheses in rats using low-virulence *Propionibacterium acnes* and *Staphylococcus epidermidis*. Even after seven weeks, no macroscopic, radiographic or histological signs of loosening were seen with these low-virulence infections. With *Staphylococcus aureus* an acute inflammatory response was seen within four weeks.

Haematogenous spread is assumed to be the mode of infection when the patient has been asymptomatic for a

prolonged period after operation. Charnley initially doubted the possibility of this mode of infection. However, well-documented cases of haematogenous infections have been reported (Charnley 1972; Ahlberg, Carlsson and Lindberg 1978). Moreover, a number of authors have successfully infected prostheses in animals by injecting organisms into the circulation (Blomgren 1981). It has been postulated that rheumatoid patients have an increased susceptibility to bacteraemia, and therefore to late haematogenous spread. These patients often have low levels of complement, and their defences against bacterial invasion may be lowered by long-term corticosteroid therapy (Fitzgerald et al. 1977; Gristina, Rovere and Shoji 1974). Another suggested cause of deep infection via the haematogenous route is catheterisation for urinary retention (Wroblewski and del Sel 1980).

Some mention must be made of the follow-up periods quoted for our series. Although no case had less than two years follow-up, the plain cement series had an average review period twice as long as that of the gentamicin series. Are these two groups then directly comparable? The authors believe that the appearance of radiological evidence of infection in all the 28 infected cases by one year suggests that the groups are comparable. All 1542 cases have been subjected to a careful follow-up and scrutiny for evidence of these radiological changes. Basing the diagnosis of deep sepsis largely on radiological evidence is, of course, subject to human error, but this error is presumably equal in the two series.

The overall rates of infection for the plain cement and gentamicin-cement series were 2.18% and 1.34% respectively. Although the difference appears consider-

Table II. Details of the infected cases: CMW series

Case	Sex	Age (years)	Interval between LFA and revision (years)	Low-friction arthroplasty		Revision	
				Risk factors	Culture†	Infecting organisms	Outcome
1	M	63	Awaiting revision (9 years)	Severe superficial thrombophlebitis in the same leg	(Radiologically infected)		
2	M	43	4	Bilateral simultaneous LFA		Negative	Further LFA. At 2 years is mountaineering
3	M	61	1	Severe bronchitis. Postoperative urinary retention		<i>E. coli</i>	Pseudarthrosis
*4	F	68	2	Austin Moore to LFA	Negative	Coag. neg. staph.	Pseudarthrosis
*5	M	71	2	McKee to LFA	Negative	Coag. neg. staph.	Pseudarthrosis
*6	F	44	4	SUFE to ITO	Not taken	Coag. neg. staph.	Further LFA. Well at 3 years
7	M	67	5	Nil		Coag. neg. staph.	Further LFA. Well at 4 years
8	F	69	1	Delayed wound healing		<i>E. coli</i>	Further LFA. Well at 5 years
*9	M	58	7	ITO to LFA	Negative	Coag. neg. staph.	Further LFA. Well at 4 years
10	M	50	1	Compound fracture of upper femur with secondary osteoarthritis		<i>Staph. aureus</i>	Further LFA. Pseudoarthrosis
*11	M	63	2	Change of fractured stem	Not taken	<i>Staph. aureus</i>	Died at 2 years—septicaemia from infected olecranon bursa
12	F	77	7	Nil		Coag. neg. staph.	Further LFA. Well at 1 year
13	M	42	6	Old septic arthritis with bony ankylosis	Not taken	Coag. neg. staph. and diphtheroids	Further LFA. Well at 2 years
14	M	30	6	Postoperative pneumonia	(<i>Strep. pneumoniae</i> and <i>E. coli</i> from sputum)	Coag. neg. staph.	Further LFA. Well at 2 years
15	M	61	1	Bilateral LFA – staged on same admission		<i>E. coli</i> (one hip)	Further LFA. Well at 3 years
16	F	55	3	Rheumatoid arthritis. Steroids. Delayed wound healing		<i>Staph. aureus</i>	Pseudarthrosis
*17	F	69	3	Fractured neck of femur, internal fixation		<i>Staph. aureus</i>	Pseudarthrosis
18	M	63	4	Rheumatoid arthritis		Coag. neg. staph.	Further LFA. Died at 2 years from <i>Staph. aureus</i> septicaemia from pressure sore
19	M	63	6	Bilateral LFA. Occult infected spinal lesion		<i>Staph. aureus</i> (both hips)	Bilateral pseudarthrosis

LFA, low-friction arthroplasty; further LFA, immediate exchange replacement

ITO, intertrochanteric osteotomy

SUFE, slipped upper femoral epiphysis

* Infected cases with previous surgery

† As cultures are not routinely taken at primary LFA, details are only given where the patient has had previous surgery

Table III. Details of the infected cases: Palacos with gentamicin series

Case	Sex	Age (years)	Interval between LFA and revision (years)	Low-friction arthroplasty		Revision	
				Risk factors	Culture	Infecting organism	Outcome
*1	M	90	1	Change of press-fit socket	Negative	<i>Staph. aureus</i>	Died with <i>Staph. aureus</i> septicaemia
2	M	39	Awaiting revision (2 years)	Ankylosing spondylitis. Bilateral simultaneous LFA	(Radiologically infected)		
*3	F	50	3	Previous osteotomy (no metal)	Not taken	Coag. neg. staph.	Further LFA. Well at 3 years
4	F	50	1	Technically difficult because of old CDH		Negative (on antibiotics)	Further LFA. Well at 1 year
5	F	60	1	Rheumatoid arthritis. Steroids. Haematoma		<i>Staph. aureus</i>	Died after further LFA
6	M	77	1	Opposite hip unresolved infected (<i>Staph. aureus</i>) pseudarthrosis	Not taken	<i>Staph. aureus</i>	Further LFA. Well at 1 year
7	F	56	1	Severe total-body atopic eczema. Steroids. Haematoma. Delayed wound healing		<i>Staph. aureus</i>	Further LFA. Well at 1 year
8	M	75	1	Epidural anaesthesia for severe bronchitis. Retained drain - sinus		<i>Staph. aureus</i>	Further LFA. Sinus persists
9	F	81	2	Delayed wound healing		Gram-positive cocci	Further LFA. Died postoperatively with bronchopneumonia

* Infected cases with previous surgery

able, it is not statistically significant. Taking both series en masse it would appear, therefore, that there is no particular advantage to be gained from the use of gentamicin cement in the prevention of deep sepsis in cases operated on in a clean air enclosure and with the surgeon wearing a total-body exhaust suit. However, considering the series in relation to previous surgery (Table I), there does appear to be an advantage in gentamicin cement. From many patients in our Group 3, metallic implants were removed. It is well recognised that such implants may be colonised by low-virulence organisms of the type which may later be responsible for the failure of hip replacement. The local bactericidal effect of gentamicin-containing cement would seem highly desirable in these cases. In Group 4 the striking difference in the two series may be accounted for by the proportion of total hip arthroplasties which were revised for component failure or "aseptic" loosening which yielded a positive culture of low-virulence organisms. Given the difficulty in culturing these low-virulence strains, it is likely that some cases of revision which gave negative cultures are, in fact, infected at the time of insertion. The local antibacterial effect of the gentamicin cement could well explain the very low infection rate recorded in Group 4.

Tables II and III indicate perioperative conditions which, in our opinion, may have resulted in deep infection; only two of the 28 infected cases had none of these conditions. The tables also show that bacteriological evidence of infection was absent in four cases: Cases

1 and 2 from the CMW series, and Cases 2 and 4 from the gentamicin series. All four, however, had gross radiographic evidence of infection, i.e. marked acetabular loosening, periostitis and cavitation. Two of these cases are awaiting revision.

There were eight infected hips that had undergone previous operations. Owing to the striking difference in infection rates between CMW cement and Palacos with gentamicin in this group of patients, we feel it is important to stress the mean time between the original operation and that performed for infection. We consider the intervals comparable but, most importantly, both are over two years: 3.3 years for CMW and 2.0 years for Palacos with gentamicin.

Our overall infection rates are within the limits quoted by other workers. To date, prophylactic systemic antibiotics have not been employed, and this has allowed a direct comparison of the efficacy of plain cement and gentamicin-impregnated cement. However, parenteral antibiotics may reduce the incidence of deep infection even further, and consideration will be given to their use in future.

One significant finding to emerge concerns the timing of the onset of infection. The 28 infected cases in our study showed evidence of infection on radiographs within one year of operation, clearly indicating that the peri-operative period was the time when deep infection was introduced. Based on our radiological findings, we believe that it should nearly always be possible to make a diagnosis of infection within one year of operation.

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