Acta orthop. scand. 46, 968–978, 1975

The Middlesex Hospital, London, W1N 8AA, England.

INFECTION FOLLOWING TOTAL HIP REPLACEMENT IN A GENERAL HOSPITAL WITHOUT SPECIAL ORTHOPAEDIC FACILITIES

M. K. D. Benson & S. P. F. Hughes

Accepted 28.iv.75

Total prosthetic replacement of the hip has become a standard orthopaedic procedure. A serious complication is for infection to occur as it results not only in pain in the hip, but it may lead to further disability and eventual removal of the whole prosthesis.

Charnley & Eftekhar (1969) investigated this problem and showed that the incidence of infection could be reduced by using a specially designed operating theatre incorporating a system of nearly sterile air with laminar flow. However, not all hospitals have these facilities and we have reviewed the incidence of infection among patients who have had a total hip replacement undertaken in a general hospital without special orthopaedic theatres.

METHOD

All total hip replacements performed at The Middlesex Hospital from 1968 to 1972 inclusive have been reviewed. There were 274 patients who had 321 arthroplasties; 202 women and 72 men. The mean age was 63 years (Figure 1) and the average follow-up period was 2 years (Figure 2).

The operations were performed in general theatres, which were built in 1936; two further theatres were added in 1968. The plan of the operating suite is shown in Figure 3. The theatres are situated on the top floor of the six-storey hospital. The clean zone includes the changing and recovery rooms; dirty material is dispersed through a clean corridor to a sluice and holding area. The scrub room is incorporated in the operating theatre, but the sterilising and anaesthetic rooms are separate. The ventilation system is designed to give a minimum of 15 air changes each hour in the theatre. Air enters from outside through high level wall ducts and is extracted through low level vents. With this system, the air flow is turbulent rather than laminar. Air filters remove particulate matter greater than 5 μm in diameter. This is an effective barrier to dust particles but not to isolated bacteria.

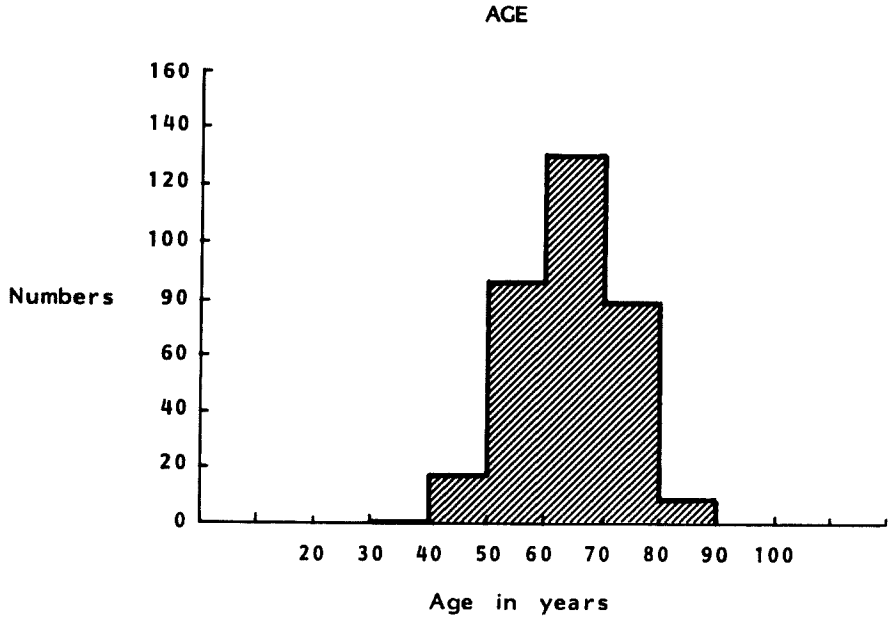

Figure 1.

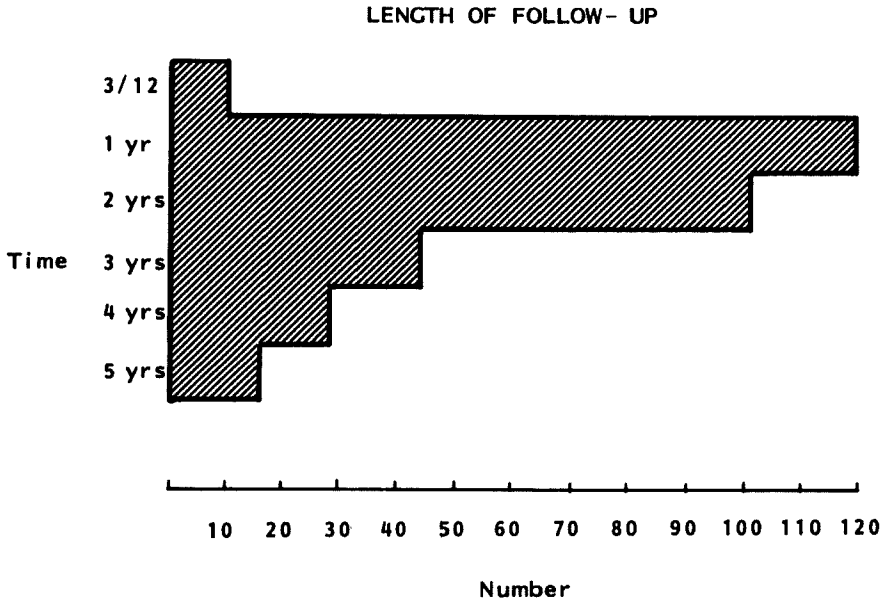

Figure 2.

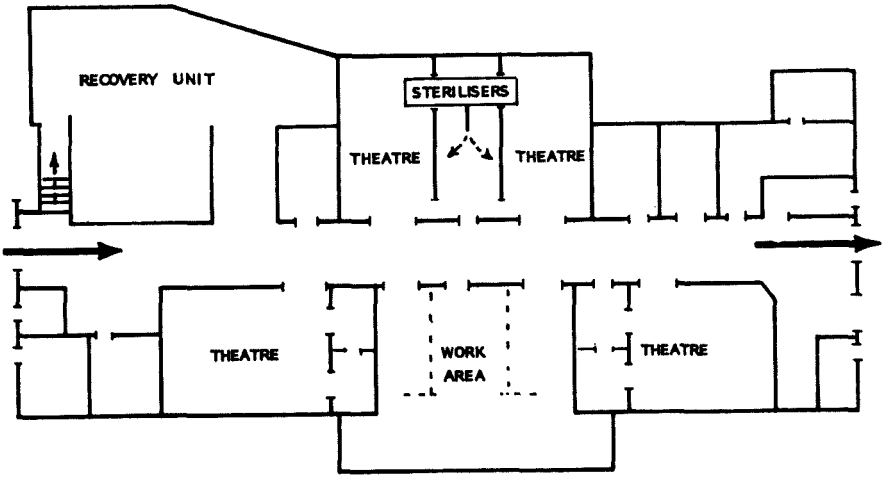

Figure 3.

However, bacteria are rarely completely unattached to particulate matter and particles which carry pathogenic bacteria have a medium diameter of 12 μm (Noble et al. 1963). In practice, therefore, a 5 μm filter is highly efficient (Blowers & Crew 1960).

No theatre is reserved entirely for orthopaedic use; general surgeons, urologists, gynaecologists, cardiothoracic and neurosurgeons all operate in these theatres. No theatre is used for 2 hours after an operation on a patient who is potentially or actually infected. In addition to the normal attendants at a major operation, there are always some medical and nursing students in the theatre itself. The spectators are encouraged to remain as still as possible, as activity has been shown to increase the content of bacteria in the air (Brøckner & Jessen 1963).

Patients are admitted to the orthopaedic ward 24 to 48 hours before operation. In the theatre, the skin is cleaned with 0.5 per cent chlorhexidene in 70 per cent alcohol. No patient received prophylactic antibiotics, but one third had chloramphenicol powder inserted into the wound at the end of the operation. A closed system of drainage was used in all patients and the types of replacement included McKee-Farrar, Charnley and Stanmore; one patient had a Howse prosthesis.

As infection following hip replacement can become apparent at any stage after the operation, we arbitrarily divided infections into those occurring early, within 3 months of the operation, and those occurring late, more than three months after the operation. The diagnosis of early infection rarely presents a problem; the patient has continuous severe pain, is obviously unwell, usually has a fever and frequently has a discharge from his wound. The white cell count is elevated and pathogenic organisms can almost always be cultured. By contrast, late infections may prove difficult to distinguish from mechanical disorders, or from immune reactions based on metal sensitivity. The patient has pain, but is generally well, frequently afebrile and often has a normal white cell count. We considered late infection to be present when two or more of the following criteria were present.

a) pain in the hip at rest and on movement.
b) a persistent sinus in communication with the hip joint.
c) pathogenic organisms isolated from the hip joint, either by discharge, aspiration or at operation.
d) an E.S.R. that is 30 mm/hour above the pre-operative level, in the absence of other causes for the elevation.
e) radiological evidence of infection; that is, periosteal reaction, bone resorption and progressive erosion of the calcar femorale.

RESULTS

Of the 321 hip arthroplasties performed, 17 became infected, an incidence of 5.3 per cent. Nine of these infections were early (2.8 per cent) and eight were late (2.5 per cent). Six of the 103 patients who had chloramphenicol powder inserted into the wound at the end of the operation developed an infection, compared with 11 out of 218 who did not. There was, therefore, no statistically significant difference in the infection rates of those patients with local antibiotic powder applied to the wound and those without.

The organism isolated from the infected hips showed a wide variety (Table 1). There was no obvious difference in the type of organism cultured from the early infections and that cultured from the late infections. It was notable that several of the organisms cultured were of the supposedly less virulent type, and are usually regarded as skin commensals only. Whether *staphylococcus albus* may be considered pathogenic and be responsible for deep infections in the abnormal environment created by a hip arthroplasty remains uncertain.

In all 17 infections, the patient complained of severe pain in the hip; although not abolished by rest, the pain was aggravated by movement. None of the patients with late infection showed signs of

Table 1. Organisms isolated.

Organism	Early	Late
Staphylococcus aureus	2	1
Escherichia coli	3	1
Proteus species	1	1
Pseudomonas aeruginosa	2	–
Streptococcus faecalis	2	1
Staphylococcus albus	2	2
Micrococci or diphtheroids	1	2

Table 2. X-ray changes in 17 patients.

Change	Minimal	Marked
Periosteal reaction	4	7
Resorption of the calcar femorale	6	5
Bone destruction	4	3

systemic upset, and none complained of general ill health or of fever. The patients who developed what was regarded as late infection were initially pain-free following their arthroplasty. Similarly, the white cell count was not raised. The E.S.R., however, was elevated, ranging from 44 to 120 mm/hour (mean 65 mm/hour). The E.S.R. varies with surgery and usually increases by about 30 mm/hour, returning to its original level at 8 weeks (Hughes 1966).

Radiographic evidence of infection about the prosthesis is shown in Table 2. The most constant findings were periosteal reaction around the shaft of the femur and resorption of the calcar. Periosteal reaction about the acetabulum was not seen even in the presence of gross acetabular loosening and migration resulting from infection. Charnley (1967) believes that resorption of the calcar is a physiological effect and that

Figure 4.

Figure 5.

the resorption confirms the efficacy of weight transmission by cement low down in the medullary cavity. In this physiological resorption, however, there is a smooth loss of the full thickness of the calcar, while in the infective process, the calcar is irregularly eroded. Bone resorption was also seen in the greater trochanter but infrequently in the femoral shaft (Figures 4 and 5).

In 10 of the 17 patients with infection, sinograms were performed and these confirmed a direct communication with one or both of the components of the hip prosthesis. Bone scans, using ethylhydroxydiphosphonate, were performed on three patients, and each demonstrated increased isotope uptake about the infected prosthesis (Figure 6).

The incidence of infection was no different, whether Consultants or Senior Registrars performed the operation. Out of 321 hip replacements, there were 118 McKee-Farrar, 161 Charnley, 41 Stanmore and one Howse. The rate of infection was 7.6 per cent, 4.8 per cent and 0 per cent; the single Howse replacement became infected. The length of follow-up for the McKee-Farrar, Charnley and Stanmore was 5, 4 and 2 years respectively, and for this reason the relative rates of infection are not statistically significant.

Of the eight patients with late infection, three gave a clear history of a recent intercurrent infection. One patient had a dental abscess and

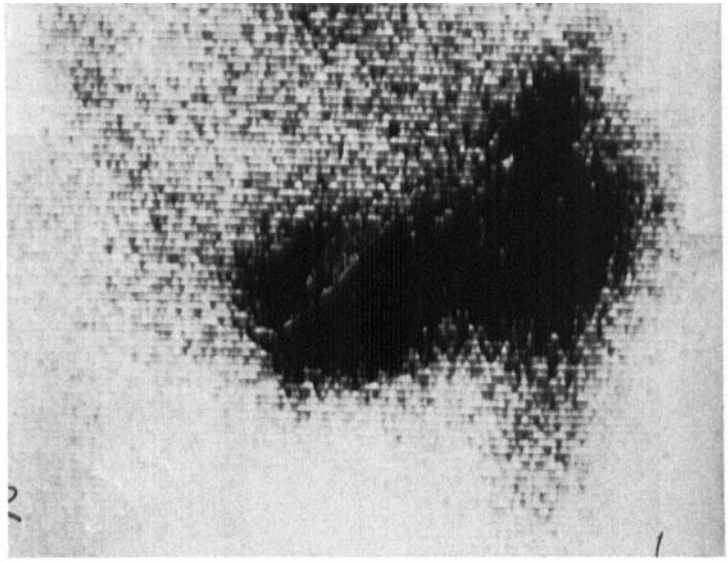

Figure 6.

one an infected ulcer; however, both these were treated before their hip infection developed and there is unfortunately no record of the pathogenic organism. The third patient had had a urinary tract infection caused by a coliform organism of exactly similar sensitivity as that subsequently isolated from the infected hip prosthesis. Three other patients had episodes of trauma to their hip prior to the onset of infection. In each case, the initial pain of their fall was completely relieved before the persistent deep pain of infection developed. No patient who had bilateral arthroplasties developed infection in both hips.

Eleven of the 17 patients with infection have had Girdlestone arthroplasties. Of the remaining six, one has died and five are either unwilling or not sufficiently incapacitated for the prosthesis to be removed.

DISCUSSION

We have found that the incidence of infection following total hip replacement in this retrospective series compares favourably with that reported by others (Table 3). Most authors (Patterson & Selby Brown 1972, Charnley 1972, Harris et al. 1972, Todd et al. 1972, Sillar & Connor 1971, Ericson et al. 1973, and Arnett 1973) agree that infection

Table 3. Comparative rates of infection.

Name	Year	Number	Early %	Late %	Total %	Type of theatre, prosthesis and prophylaxis
Charnley	1965	582	1.6	2.2	3.8	Special orthopaedic theatre. 130 air changes/hour. Charnley. No prophylaxis.
Charnley	1969	708	1.0	0.3	1.3	Special orthopaedic theatre. 300 air changes/hour. "Laminar flow". Charnley. No prophylaxis.
Roles	1971	471	–	–	5.9	General theatre. Knees and hips replaced. Mixed prophylactic antibiotics.
Sillar	1971	60	1.6	1.6	3.2	Orthopaedic theatre. Charnley. Gentamycin. Cloxacillin and Ampicillin.
Harris	1972	73	7.0	3.8	10.8	General theatre. Charnley. Rheumatoid arthritis, Ampicillin and Cloxacillin.
Todd	1972	320	2.5	2.8	5.3	General theatre. Charnley. Ampicillin and Cloxacillin.
Patterson	1972	368	2.99	5.16	8.15	Orthopaedic theatre. McKee. No prophylaxis.
Ericson	1973	83	0	–	0	Orthopaedic theatre.
		60	–	0	0	Charnley. Probenecid and Cloxacillin.
Coventry	1974	2,012	–	–	0.6	Orthopaedic theatre. Charnley. Methicillin.
The Middlesex	1974	321	2.8	2.5	5.3	General theatre. McKee, Charnley, Stanmore and Howse. No prophylaxis.

following prosthetic replacement may occur either early or late. There is disagreement, however, as to why late infections occur. Late infections may arise because bacteria introduced at the time of the operation become activated, or because the prosthesis may be the site for bacteria to settle during a bacteraemia. A significant bacteraemia may be produced by trauma, burns or intercurrent infections (Lerner &

Weinstein 1966 a) and the possible effects of a bacteraemia on patients who have damaged heart valves are well established. Patients with abnormal heart valves are advised to avoid these procedures, including dental or urological manipulations, which might provoke bacteraemia, unless they are adequately protected by prophylactic antibiotics (Lerner & Weinstein 1966 b). It may be that patients with hip prostheses should be similarly protected.

Certainly, intercurrent infections, no matter how trivial, should be treated with the appropriate antibiotics for a period sufficient to cover any bacteraemia which may arise. Similarly, all injuries to the hip joint should be taken seriously and the patient given a prophylactic antibiotic, as a local haematoma formation following such an accident may act as a suitable culture medium for bacteria to grow and for infection to take place.

In order to reduce the per-operative rate of infection, Charnley (1968) has paid particular attention to the air in the theatre. He operates in an isolated chamber in which the air is filtered to 1 μm and delivered at 4,500 cf/min. A system of aluminium diffusion vanes attempts to distribute the air flow in a linear fashion. Air enters through the ceiling and is dispersed at ground level; it is changed 300 times per hour. The air inside the operating enclosure is, therefore, of high sterility and the ventilation approximates as closely as possible to the ideal of laminar flow. To prevent bacterial contamination by the surgeon and his assistants, each wears a totally investing helmet and gown with individual exhaust systems to remove convection currents, skin scales and exhaled breath.

In a busy general theatre such as that of The Middlesex, used by a variety of surgical specialities, such a system would be difficult to emulate. Therefore, in addition to standard precautions against infection, the use of prophylactic antibiotics may be considered. Scales et al. (1972) reviewed 1,623 patients who had metal implanted during various orthopaedic operations and found that the incidence of wound infection could be reduced from 8.8 per cent to 5.3 per cent by introducing antibiotics into the wound during the operation. In our patients, however, the use of chloramphenicol powder made no difference to the infection rate, early or late. Coventry et al. (1974) reported a 0.6 per cent infection rate, following total hip replacement. They gave Methicillin systemically as a prophylactic and operated in theatres reserved entirely for orthopaedic use. Ericson et al. (1973) showed that prophylactic Cloxacillin can reduce the infection rate from

13 per cent to 0 per cent in early infection and from 14 per cent to 0 per cent in late infections. However, the total follow-up was only 2½ years; their series included fractured necks of femurs and the operations were performed entirely in orthopaedic theatres. Because of the wide variety of organisms cultured from infected hip prostheses, we believe that a single anti-staphylococcal antibiotic may not be adequate protection and that a broader spectrum antibiotic given systemically at the time of the operation may be more effective.

SUMMARY

Infection following total hip replacement is a serious complication for it is frequently impossible to resolve without removal of the prosthesis.

We have reviewed 321 total hip replacements undertaken in a general hospital without special orthopaedic theatres. There were 17 deep infections, nine early and eight late. Although the diagnosis of early infection is usually not difficult, the differentiation between late infections, mechanical failure and metal sensitivity may be a problem. This paper discusses the use of ESR, radiographs, isolation of pathogenic organisms and bone scanning in reaching the diagnosis of infection of the hip.

There is possibly a parallel between prosthetic infection and subacute bacterial endocarditis. Therefore all intercurrent infections and episodes of trauma should be given an adequate course of a broad spectrum antibiotic. Sterile air and laminar flow systems are discussed and compared with prophylactic antibiotics, both systemic and local, in attempting to reduce the overall rate of infection following total replacement of the hip.

ACKNOWLEDGEMENTS

We should like to express our thanks to Mr. P. H. Newman and Mr. D. R. Sweetman for allowing us to study their patients, and to Mr. Sweetman and Dr. R. E. M. Thompson for their help and advice in preparing this paper.

REFERENCES

Arnett, J. H. (1973) Delayed infection after total hip replacement. *J. Amer. med. Ass.* **223**, 1042.

Blowers, R. & Crew, B. (1960) Ventilation of operating theatres. *J. Hygiene* **58**, 427.

Brøckner, J. & Jessen, C. (1963) Risk of airborne infection at operation. *Acta chir. scand.* **125**, 8.

Charnley, J., Follacci, F. M. & Hammond, B. T. (1967) The long-term reaction of bone to self-curing acrylic cement. Centre for Hip Surgery, Wrightington Hospital. Internal Publication No. 9.

Charnley, J. (1968) Clean air operating room enclosure. Centre for Hip Surgery, Wrightington Hospital. Internal Publication No. 13.

Charnley, J. & Eftekhar, N. (1969) Post-operative infection in total prosthetic replacement arthroplasty of the hip joint. *Brit. J. Surg.* **56**, 641.

Charnley, J. (1972) The long-term results of low friction arthroplasty of the hip performed as primary intervention. *J. Bone Jt Surg.* **54**-B, 61.

Coventry, M. B., Beckenbaugh, R. D., Nolan, D. R. & Ilstrup, D. M. (1974) 2,012 total hip arthroplasties; a study of post-operative course and early complications. *J. Bone Jt Surg.* **56**-A, 273.

Ericson, C., Lidgren, L. & Lindberg, L. (1973) Cloxacillin in the prophylaxis of post-operative infections of the hip. *J. Bone Jt Surg.* **55**-A, 808.

Harris, Jacqueline, Lightowler, C. D. R. & Todd, R. C. (1972) Total hip replacement in inflammatory hip disease using the Charnley prosthesis. *Brit. med. J.* **2**, 750.

Hughes, S. P. F. (1966) The change in the ESR following surgery. A report to the St. Mary's Hospital Orthopaedic Club.

Lerner, P. I. & Weinstein, L. (1966 a) Infective endocarditis in the antibiotic era. *New Engl. J. Med.* **274**, 199.

Lerner, P. I. & Weinstein, L. (1966 b) Infective endocarditis in the antibiotic era. *New Engl. J. Med.* **274**, 388.

Noble, W. C., Lidwell, O. M. & Kingston, D. (1963) The size distribution of airborne particles carrying micro-organisms. *J. Hygiene* **61**, 385.

Patterson, F. P. & Selby Brown, C. (1972) The McKee-Farrar total hip replacement. *J. Bone Jt Surg.* **54**-A, 257.

Roles, N. C. (1971) Infection in total prosthetic replacement of the hip and knee joints. *Proc. roy. Soc. Med.* **64**, 636.

Scales, J. T., Towers, A. G. & Roantree, B. M. (1972) The influence of antibiotic therapy on wound inflammation and sepsis associated with orthopaedic implants. *Acta orthop. scand.* **43**, 85.

Sillar, W. & Conner, A. N. (1971) Total hip replacement. Initial experience with the Charnley low friction arthroplasty. *Scottish med. J.* **16**, 228.

Todd, R. C., Lightowler, C. D. R. & Harris, Jacqueline (1972) Total replacement in osteoarthrosis using the Charnley prosthesis. *Brit. med. J.* **2**, 752.

Key words: infection; total hip replacement; general hospital

Correspondence to:

S. P. F. Hughes
The Middlesex Hospital
London W1N FAA
England