Bacterial contaminants and antibiotic prophylaxis in total hip arthroplasty

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We have investigated the contaminating bacteria in primary hip arthroplasty and their sensitivity to the prophylactic antibiotics currently in use. Impressions (627) of the gloved hands of the surgical team in 50 total hip arthroplasties were obtained on blood agar. The gloves were changed after draping, at intervals of 20 minutes thereafter, and before using cement. Changes were also undertaken whenever a visible puncture was detected. The culture plates were incubated at 37°C for 48 hours. Isolates were identified and tested for sensitivity to flucloxacillin, which is a recognised indicator of sensitivity to cefuroxime. They were also tested against other agents depending upon their appearance on Gram staining.

We found contamination in 57 (9%) impressions and 106 bacterial isolates. Coagulase-negative staphylococci were seen most frequently (68.9%), but we also isolated *Micrococcus* (12.3%), diphtheroids (9.4%), *Staphylococcus aureus* (6.6%) and *Escherichia coli* (0.9%). Of the coagulase-negative staphylococci, only 52.1% were sensitive to flucloxacillin and therefore to cefuroxime. We believe that it is now appropriate to review the relevance of prophylaxis with cefuroxime and to consider the use of other agents.

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©2005 British Editorial Society of Bone and Joint Surgery
doi:10.1302/0301-620X.87B9.15685 \$2.00

J Bone Joint Surg [Br]
2005;87-B:1256-8.
Received 28 May 2004;
Accepted after revision
21 April 2005

Although infection after total hip arthroplasty (THA) may be caused by haematogenous seeding, it is more commonly due to bacteria entering the wound at the time of surgery.^{1,2} The main sources of contamination are the skin flora of the patient and airborne bacteria from theatre personnel and the environment of the operating theatre.^{3,4} In order to address this problem, various measures have been introduced to control the operating environment. These have included the use of laminar air flow^{1,4} and Charnley's ultraclean air system, comprising sterile hoods and a body-exhaust system, which has reduced rates of infection from 9% to 1.3%,^{1,3-5} and prophylactic antibiotics.⁶ However, for the latter to be effective, they should be active against the pathogens most likely to contaminate surgical wounds.⁷ Many studies have demonstrated an increase in bacterial resistance against some antibiotics.⁸⁻¹⁰ Most post-operative prosthetic hip infections are caused by Gram-positive cocci, predominantly staphylococci.^{1,2} Recently, beta-lactam-resistant staphylococci have become increasingly common,¹¹⁻¹⁴ reducing the efficacy of antibiotic prophylaxis using penicillins or cephalosporins. Our review of the available literature showed that most studies of antibiotic pro-

phylaxis were carried out in the 1980s and 1990s.¹⁵⁻¹⁸

We undertook this study in order to identify the contaminating bacteria in our hip arthroplasty practice and to establish their sensitivity to prophylactic antibiotics in current use.

This work follows an earlier study carried out at our institution¹⁹ which highlighted significant levels of glove contamination in hip arthroplasty.²⁰

Materials and Methods

During the course of 50 THAs impressions of the gloved hands of the principal surgeon, first assistant and scrub nurse were obtained on sterile culture media (blood agar), immediately before the gloves were either changed or discarded. We only included the outer gloves in this study.

Gloves were changed after draping and thereafter either at intervals of 20 minutes or immediately before using cement, if this occurred before the end of a 20-minute interval, and whenever a visible puncture was detected. Impressions of both hands were obtained on the same blood agar plate. Culture plates were sent to the microbiology department for incubation at 37°C for 48 hours and a consultant microbiologist (DH) reported the

Table I. Bacteria isolated and their sensitivity to a variety of antibiotics in 106 patients

Bacteria	Number of isolates (%)	Sensitivity*							
		CN	LZN	FD	CXM	MT, FLX	AML	TZP	CAZ
		Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)	Number (%)
Coagulase-negative staphylococcus	73 (68.9)	70 (95.9)	73 (100)	65 (89.4)	38 (52.1)	38 (52.1)			
<i>Staph. aureus</i>	7 (6.6)	6 (85.7)	7 (100)	6 (85.7)	5 (71.4)	5 (71.4)			
<i>Micrococcus</i>	13 (12.3)	13 (100)	13 (100)	13 (100)	9 (69.2)	9 (69.2)			
Diphtheroids	10 (9.4)	10 (100)	10 (100)	8 (80)	8 (80)	8 (80)			
<i>E. coli</i>	1 (0.9)	1 (100)			1 (100)				
<i>Pseudomonas</i>	2 (1.9)	2 (100)					1 (100)	2 (100)	1 (50)

* AML, amoxicillin; CAZ, ceftazidine; CN, gentamicin; CXM, cefuroxime; FD, fusidic acid; FLX, flucloxacillin; LZN, linezolid; MT, methicillin; TZP, piperacillin/tazobactam

results. All isolates were identified by Gram stain and basic identification tests such as catalase, coagulase and oxidase reactions. The isolates were then tested for sensitivity to flucloxacillin, a recognised indicator of sensitivity to cefuroxime. Methicillin resistance implies clinical resistance to all beta-lactam antibiotics, including the cephalosporins.²¹ We also tested Gram-positive isolates against gentamicin, fusidic acid and linezolid *Escherichia coli* against gentamicin, cefuroxime and amoxicillin and *pseudomonas* species against gentamicin, ceftazidime and piperacillin/tazobactam.

Results

Impressions of 627 pairs of gloved hands were included in the study, of which 57 (9%) were found to be contaminated. There were 106 bacterial isolates, of which coagulase-negative staphylococcus was the most common, followed by *Micrococcus* species and diphtheroids. *Staphylococcus aureus* was also identified as were *Pseudomonas* species and *E. coli* (Table I).

Only 38 (52.1%) of the isolates of coagulase-negative staphylococcus were found to be sensitive to flucloxacillin and therefore to cefuroxime, although 89.4% were sensitive to fusidic acid and 95.9% to gentamicin.

For *Staph. aureus*, 71.4% were sensitive to flucloxacillin and therefore to cefuroxime while 85.7% were sensitive to fusidic acid and gentamicin. For the *Micrococcus* species, 69.2% were sensitive to flucloxacillin and all to fusidic acid and gentamicin.

For the isolated diphtheroids, 80% were sensitive to flucloxacillin and fusidic acid and all to gentamicin. All Gram-positive isolates (n = 103) were sensitive to linezolid.

The one isolated coliform was sensitive to all the agents tested. Both *Pseudomonas* species isolated were sensitive to gentamicin, piperacillin and tazobactam, although one isolate was resistant to ceftazidime.

Discussion

The role of theatre ventilation, theatre clothing and prophylactic antibiotics is undisputed in reducing the rate of deep infection after THA. The rates of infection have been reduced from 9.5% in 1964, for operations performed in unventilated theatres,²² to the current rate of 0.3% in

Sweden²³ and 1.4% in the UK²⁴ for more modern designs of operating theatres. Our findings question whether cefuroxime is the most appropriate agent for antibiotic prophylaxis since staphylococci represented 75% of contaminating isolates, nearly half of which were resistant to it.

In a study from Wrightington Hospital, Wigan, UK, tissue samples were collected for bacteriological study during primary and revision hip surgery.¹² It was found that coagulase-negative staphylococcus was the most common isolate (43.4%), 55% being methicillin-resistant. We can therefore confidently infer that those isolates were also resistant to cefuroxime. Coagulase-negative staphylococcus displays nearly total cross-resistance to cephalosporins, including cefuroxime.²¹

The proportion of coagulase-negative staphylococcus in infected THAs has varied between 5% and 70%.¹⁴ James et al¹¹ found that 18 of 30 positive bacteriological cultures from tissue samples collected at surgery showed *Staphylococcus epidermidis*, 12 of which (67%) were methicillin-resistant (MRSE). In the same study, MRSE was cultured from 25 of 100 skin swabs collected from 100 consecutive patients at the time of admission for THA. The authors expressed their concern about the use of cefuroxime as a prophylactic agent. However, despite this, cefuroxime is still a commonly-used prophylactic antibiotic for joint replacement surgery in the UK and has been extensively studied.²⁵⁻²⁸

Patterns of bacterial resistance vary with both time²⁹ and location.^{30,31} However, since 95% of our isolates were sensitive to gentamicin, it seems appropriate to continue the use of this agent in the bone cement used at THA. We also found that all our Gram-positive bacterial isolates were sensitive to linezolid, a relatively new agent, although some might argue that it should be reserved for the treatment of significant, multiresistant infections with Gram-positive organisms in order to limit the emergence of bacterial resistance to the antibiotic. We did not test our isolates against vancomycin because disc testing is known to be unreliable for this.³² However, vancomycin resistance in staphylococci is rare.³³

In 1999, Glenney and Song¹⁸ undertook a systematic review of antimicrobial prophylaxis in THA and concluded that the universal acceptance of a fixed antimicrobial regi-

men should be avoided in order to minimise the development of resistance to antibiotics. They also recommended that local guidelines, based upon available evidence should be developed by surgeons, microbiologists and pharmacists, taking into account the local sensitivities of the organisms commonly implicated in infected THAs. These guidelines should be continuously reviewed and updated since no definitive version could be established.¹⁸

From our study, it is difficult to draw firm conclusions about which prophylactic antibiotics to use since bacterial sensitivities can change over time and between different geographical areas. However, we believe that it is now appropriate to review the role of cefuroxime in prophylaxis and to consider further work in order to identify the best prophylactic agents.

Supplementary Material

A further opinion by Mr Dietmar König is available with the electronic version of this article on our website at www.jbjs.org.uk

This study had been funded from Professor P J Gregg research fund and the bacteriological studies were conducted in Microbiology Department, James Cook University Hospital.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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