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The microbiology of infected hip arthroplasty

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Abstract Infection following joint replacement surgery although rare presents a challenging problem. Bacterial resistance to antibiotics is an emerging problem. We analysed the microbiology of 337 single-stage revisions for deep infection. Coagulase negative staphylococcus was found to be the predominant organism, although staphylococcus aureus is gaining importance. Gentamicin only provides cover for 64.1% of organisms. Resistance to this commonly used antibiotic prophylaxis is escalating. Fusidic acid and erythromycin provide improved cover. We would suggest on a microbiological basis that these antibiotics be considered for addition to acrylic bone cement. This will provide local antibiotic delivery when performing a revision for deep infection.

Résumé Les infections après prothèses articulaires sont un problème difficile à résoudre, d'autant que les résistances aux antibiotiques deviennent de plus en plus marquées. Nous avons analysé la microbiologie de 337 révisions en même temps, pour infection profonde. Un staphylocoque coagulase négatif a été trouvé comme micro-organisme prédominant bien que le staphylocoque doré soit en augmentation. La gentamicine n'est efficace que sur 64,1% des micro-organismes. La résistance à cet antibiotique utilisé communément en prophylaxie va croissant. L'acide fusidique et l'érythromycine donnent une meilleure couverture en prévention. Nous suggérons que sur la base de ces analyses microbiologiques, ces antibiotiques soient ajoutés de façon traditionnelle au ciment acrylique. Ceci

donnera un meilleur résultat des antibiotiques sur le plan local lorsque l'on pratique une révision d'une prothèse articulaire pour infection.

Introduction

Joint replacement when carried out for appropriate indications delivers high patient satisfaction. The majority of patients are relieved of their preoperative pain and disability. Despite its high success rate the operation is not without complications. Of all the potential complications, infection is probably the most feared. The use of laminar airflow, exhaust suits, intra-venous antibiotics and antibiotic-loaded acrylic bone cement all contribute to reducing infection rates [1]. Although infection rates remain relatively low [2] with emerging bacterial resistance, its occurrence can be increasingly difficult to eradicate.

Prosthesis-related infection occupies a unique position in the microbiological arena. The organisms implicated in the infected arthroplasty are usually considered relatively benign organisms or simple contaminants.

Gristina describes 'the race for the surface'. His work suggests that these less virulent organisms become entrapped within an inert biofilm and hence avoid the effects of conventional antibiotic therapy [3].

It is a concern that these very organisms are now developing resistance to commonly used antibiotics [4]. In this paper we hope to delineate the microbiology of the infected arthroplasty, identify patterns of emerging resistance over the past 30 years and suggest appropriate antibiotic regimens.

Materials and methods

We conducted a retrospective review carefully analysing the infected revisions conducted under the care of the two senior authors (BMW, PRK). Three hundred and thirty-seven single-stage revisions were performed for deep infection between May 1974 and November 2005. All case

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notes were carefully reviewed by a single observer. The details collected were clinical history, the use of antibiotics pre- and postoperatively, the use of additional antibiotics in acrylic bone cement, the microbiology of peroperative specimens and their resulting sensitivity profiles.

Deep infection can often be difficult to diagnose. No true definition of deep infection exists. Positive microbiology may not necessarily indicate true deep sepsis and may simply reflect contamination. Contamination rates of the order of 63% have been reported in the primary arthroplasty setting [5]. It is generally accepted that multiple positive microbiology avoids detecting such contamination [6]. Many diagnostic modalities have been investigated, including frozen section [7], histology [6] and PCR (polymerised chain reaction) [8]. Some have suggested that infection can only be defined using a combination of these modalities [9].

In this study infection was defined both clinically and microbiologically. All 337 cases were thought clinically to be infected. Multiple specimens were sent from each case prior to the administration of prophylactic intra-venous antibiotics. Positive microbiology was defined according to the criteria laid down by the Oxford group [6]. A single positive culture on direct plating or multiple positive cultures of the same organism on enrichment media were considered positive.

Despite the presence of discharging sinuses and overt intraoperative sepsis, eighty-two cases were found to be sterile. This can probably be accounted for by the use of preoperative broad spectrum antibiotics used in an attempt to suppress infection. For the purposes of this study these eighty-two cases were excluded.

Thus, 255 cases were found to be both clinically and microbiologically infected. The microbiology of these cases and their sensitivity profiles were carefully assessed. In 219 cases, a single significant organism was cultured. Thirty-six cases grew two separate organisms which were both thought to be clinically significant.

This resulted in 291 bacterial isolates and their sensitivity profiles to examine. The organisms were plated out against the antibiotics listed in Table 1. Due to the historical nature of the data analysed this list does not include some of the more modern antibiotics that might make up the antimicrobial armamentarium today.

Table 1 Antibiotics used to plate out organisms

Antibiotic group	Antibiotic
Penicillin	Penicillin
Penicillin	Methicillin
Macrolide	Erythromycin
Fusidic acid	Sodium fusidate
Aminoglycoside	Gentamicin
Cephalosporin	Cefradine

Fig. 1 Pi chart depicting microbiology of the infected total hip replacement, 1974–2005

Results

Figure 1 shows in pi chart format the prevalence of these organisms. Gram positive organisms account for most bacteria. Coagulase negative staphylococci predominate (67%), with *Staphylococcus aureus* (13%), *E. Coli* (6%) and streptococci (9%).

Figure 2 shows how bacteriology has evolved from 1974 to 1999.

Coagulase negative staphylococcus is the most common organism infection of the total hip replacement, as can be seen from Figs. 1 and 2. However the line diagram in the figure shows how bacteriology is changing. The pink line shows staphylococcus aureus appears to be increasing in its prevalence.

Figure 3 shows the overall sensitivity profiles to the antibiotics listed in Table 1. The blue segment of the bar shows sensitivity and the red segment resistance. The penicillin group, i.e., penicillin and methicillin, are surprisingly not poor at dealing with organisms infecting the total hip replacement. Cefradine, a second generation cephalosporin, is only marginally better. Gentamicin is shown in the fourth column. Overall resistance to gentamicin was found to be 23.9%. Erythromycin and fusidic acid seem to fare much better.

Fig. 2 Changing bacteriology in the infected total hip replacement 1974–2005

Fig. 3 Sensitivity of all organisms at THR to antibiotics

Figure 4 shows the relative effectiveness of the antibiotics listed in Table 1 to the two most common organisms: coagulase negative staphylococcus and *Staphylococcus aureus*. This graph shows that most of the antibiotics have similar activities against both micro-organisms. However, methicillin appears to be more active against SA than CNS. This would suggest that in our series methicillin-resistant staphylococcus epidermidis (MRSE) is more of a problem than methicillin-resistant staphylococcus aureus (MRSA) in joint replacement surgery.

Figures 5 and 6 show how sensitivity profiles have changed against the two main organisms: coagulase negative staphylococcus and *Staphylococcus aureus*.

Coagulase negative staphylococcus (CNS) (Fig. 5)

Between 1974 and 2005, flucloxacillin, penicillin and gentamicin have become decreasingly effective against CNS. Fusidic acid and erythromycin, however, have improved.

Staphylococcus aureus (SA) (Fig. 6)

With respect to *staphylococcus aureus* (Fig. 6), penicillin has similarly declined in its effectiveness. Fusidic acid and erythromycin are improving in efficacy. Methicillin, however, with respect to SA appears to be maintaining its effectiveness. This suggests again that MRSA is not a significant problem with respect to arthroplasty surgery.

Discussion

It is important to understand the microbiology and evolving patterns in the infected joint replacement. The data presented in this paper confirm that CNS remains the most common organism at revision for deep infection. This would suggest that contamination rather than blood borne spread is the most common mechanism of infection. The microbiological makeup of arthroplasty is changing. Figure 2 shows in graph form that although CNS remains the most important organism, SA is developing into a more

Fig. 4 Relative sensitivity of antibiotics to coagulase negative staphylococcus (CNS) and *Staphylococcus aureus* (SA)

Fig. 5 Changing sensitivity patterns to CNS over time. 1974–2005

widespread organism. If these trends continue over the next 20 to 30 years SA may become increasingly significant with respect to joint replacement surgery. This is clearly an alarming feature especially as MRSA and VRSA are becoming increasingly prevalent in the community.

The sensitivity profiles are changing and it is not surprising that with time more resistant strains are emerging. Our study confirms that gentamicin resistance in arthroplasty is a real problem with 23.9% of organisms being resistant. The aminoglycosides antibiotics remain the most common form of antibiotic prophylaxis within acrylic bone cement. Since its introduction by Bucholz in the early 1980s one can see from Figs. 5 and 6 that its effectiveness at dealing with infection has declined. One can only expect this to worsen.

Fig. 6 Changing sensitivity patterns to SA over time. 1974–2005

Our data suggest that other antibiotics such as fusidic acid and erythromycin still remain highly effective against these organisms.

Conclusion

The infected arthroplasty remains a difficult and challenging problem to the modern orthopaedic surgeon. Understanding the bacteriology and its evolution is an important part of our armamentarium. The evidence suggests that this is an ongoing process and we are likely to encounter more virulent strains in the future. The data presented in this paper help to rationalise antibiotic strategies in treating the infected arthroplasty and also may help us to avoid the multi-resistant virulent forms of these bacteria.

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