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Characterisation of aerobic bacteria isolated from orthopaedic implant-associated infections

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Abstract:

BACKGROUND AND OBJECTIVES: Orthopaedic implant-associated infections (OAIs) are challenging to treat, as it may result in high chances of implant removal and causes huge financial burden due to absenteeism, disability, hospital stay and cost of treatment. Early detection of the infection and prompt antimicrobial therapy is very important. The study was undertaken to identify the pathogens causing OAI and their antibiogram and to formulate the antibiotic policy accordingly.

METHODOLOGY: It was a prospective observational study carried out for a period of one year (January 2016 to December 2016) in the Department of Microbiology and Orthopaedics in a tertiary care centre. All patients with suspected OAI, who were admitted to the hospital, were included in the study. The pus or wound swab from these patients was tested for the pathogens and their antibiogram.

RESULTS: A total of 1628 implant surgeries were conducted during the study period, of which 136 patients suspected to have OAI, amongst them 81 (59.55%) had bacterial growth. The Orthopaedic implant infection rate was 4.9%. The most common pathogen isolated was *Staphylococcus aureus* and of which 30.43% were methicillin-resistant strains. The most common site affected was tibia (41.97%). The majority (27.16%) of the patients had developed implant-associated infection within six months of the implant surgery.

CONCLUSIONS: The OAIs it greatly affects the quality of life of the individual. Early suspicion, prompt investigation and timely treatment can reduce the morbidity caused by the OAI. Since the pathogens causing OAI can vary in hospital, the local bacterial profile of the pathogen causing OAI and their antibiogram needs to be monitored to treat the patients effectively for better outcome.

Keywords:

Aerobic culture, high-efficiency particulate air filter, Methicillin-resistant *Staphylococcus aureus*, orthopaedic implant infections

Introduction

Orthopaedic implants are devices intended to restore the function of load-bearing joints which are subjected to high levels of mechanical stress and fatigue.[1] The introduction of an implant in the body is always associated with the risk of microbial infection, leading to implant failure and joint-revision surgeries. The implant can get infected by the bacteria or fungi due to reducing host defence mechanism at the site of implantation. It is a challenging task to treat orthopaedic implant infections which may lead to implant replacement and may result in amputation, in turn, causing huge financial burden due to absenteeism from job, disability, hospital stay and cost of treatment. The risk of orthopaedic implant-associated infection (OAI) may vary from 0.4% to 16.1% i.e., for closed fracture to complicated open fracture.[2,3] The early OAI, which occurs within one month of implantation, mainly acquired exogenously, which can be

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treated with the implant *in situ*. The source of infection includes the environment of the operating room (OR), surgical equipment and clothing worn by medical and paramedical staff and colonisers and commensals on the patient's body. The most common pathogens were Gram-positive Staphylococcus, Streptococcus and sometimes even Gram-negative bacteria. In contrast, chronic OAI, which occurs after two years of implantation, is usually acquired haematogenously and caused by biofilm-producing bacteria, such as coagulase-negative staphylococci, requires implant removal with or without replacement. Numerous risk factors have been identified such as rheumatoid arthritis, immunocompromised states, diabetes mellitus, poor nutritional status, obesity, psoriasis, long-term urinary catheterisation, extreme age and HIV infection.[4] Majority of these implant-associated infections are the result of bacterial adhesion to the implant surface and subsequent biofilm formation at the implantation site.[5]

In India, the incidence of SSI is reported to be 6% in implant and non-implant-associated surgeries as a whole.[6] Thus, the identification of factors that cause or predict these infections continues to be an important area of research. The incidence of surgical site infection (SSI) varies from hospital to hospital and also from time to time. A wide variety of aerobic and anaerobic species of bacteria may be present, either singly or in combination. Infections of wounds are generally associated with the production of pus and the bacteria involved are said to be 'pyogenic'.[7] The specific microbiology of an orthopaedic wound infection has an impact on the severity, onset and even the outcome of infection due to differences in rates of growth, ability to survive in the host environment and virulence. The study was undertaken to identify the pathogens causing OAI and their antibiogram and to update the antibiotic policy accordingly for pre-surgical prophylaxis of orthopaedic implant surgeries and treatment of OAI.

Methodology

It was a prospective observational study carried out for a period of one year from January 2016 to December 2016, in the Department of Microbiology and Orthopaedics at Father Muller Medical College Hospital, Mangalore, after the clearance from the Institutional Ethical and Research Committee was obtained. Pus samples and wound swabs collected from patients with suspected OAIs were included in the study. . The Gram's staining of the samples showing epithelial cells and <10 or no pus cells per low-power field was considered as contaminant/coloniser and was excluded from the study. The samples which were included in the study were cultured aerobically on 5% sheep blood agar and MacConkey's agar according to the standard operating guidelines. After overnight incubation, growth appearing on the plate was identified with Gram's staining and routine biochemical reactions. Antibiotic susceptibility testing was performed on Mueller-Hinton Agar using Kirby–Bauer disc diffusion method, according to the Clinical and Laboratory Standards Institute guidelines.[8] The inoculated plates were incubated for 72 h and declared no growth if no bacterial colonies were grown. Statistical analysis of the data was performed using SPSS software 2015 with Chi-square test and Fisher's exact test.

Results

A total of 1628 implant surgeries were conducted during the study period of which 152 patients were provisionally diagnosed with OAI, and their pus or and wound swabs were received during the study period. Sixteen patients were excluded from the study as their samples were characteristic of contaminant/coloniser based on Gram staining. Out of the remaining 136 samples, 81 (59.5%) had growth and 89 pathogens were isolated (eight samples were polymicrobial). The most common pathogen isolated was *Staphylococcus aureus* (46/89 [51.6%]) [Table 1], which was found to be statistically highly significant (P = 0.0001). Nearly one-third of these, 14 of 46(30.43%), were *Methicillin-resistant S. aureus* (MRSA). *S. aureus* prevalence was found to more in males (31/46), but this male–female difference was not statistically significant (P = 0.359). All these MRSA-isolated patients were treated with intravenous *Vancomycin*. Other common pathogens isolated were *Pseudomonas aeruginosa* (9/89 [10.1%]), *Acinetobacter baumannii* (7/89) and *Enterococcus faecalis* (6/89).

More than 50% of the cases were of the age group between 16 and 45 years, but the most common age group affected was 31–45 years (30.8%) [Table 2]. This can be attributed to the fact that majority of these cases was road traffic accidents. The most common co-morbid condition for developing OAI was diabetes mellitus on

Table 1: Distribution of pathogens isolated from the implant infection

Organism isolated	Total number	Male	Female
Staphylococcus aureus	46	31	15
Coagulase Negative Staphylococcus	8	3	5
Acinetobacter baumanii	7	5	2
Pseudomonas aeruginosa	9	7	2
Enterococcus faecalis	6	6	0
Escherichia coli	4	2	2
Citrobacter koseri	4	3	1
Klebsiella pneumoniae	2	2	0
Streptococcus pyogenes	2	2	0
Streptococcus agalactiae	1	1	0
Total	89	62	27

insulin therapy, accounting for about 16% (P = 0.042), followed by hypertension and COPD. The most common site affected was tibia (34/81 [41.97%]) [Figure 1]. The OAI rate in this study was around 4.9%. Of 81 patients, 22 (27.1%) developed implant-associated infection between one and six months of the implant surgery [Table 3] and 17/22 (77.2%) of these patients underwent a second surgery for the implant removal. The number of days of hospital stay following the infection was also looked into, which revealed that infection with *A. baumannii* was associated with the maximum number of days of hospital stay with an average of 38 days.

Discussion

In 2002, Klevens *et al*. have reported that approximately 20% of total healthcare-associated infections (HAIs) were SSIs in the US hospitals.[9] In the present study, pathogens were isolated in 81 of 136 suspected cases of OAI and *S. aureus* 46/89 (51.6%) was the most common pathogen. Amongst which 14/46 (30.43%) were MRSA. In Indian Scenario, *S. aureus* has been an important cause of SSI in less than one month postoperatively. The prevalence of *S. aureus* ranges from 29% to 63%.[2,3,10] From this study, we noted that the MRSA isolation in SSI was as high as 30.43% i.e., 14 amongst 46 *S. aureus* isolate. It helped us to formulate MRSA screening policy for patients undergoing implant surgery in all departments including orthopaedics.

Table 2: Age-wise distribution of the patient who had orthopaedic implant infections

Age (years)	Number of patients (%)
<16	5 (6.17)
16-30	21 (25.9)
31-45	25 (30.86)
46-60	16 (19.75)
>60	14 (17.28)
Total	81

Table 3: Duration of post-operative period in which cases presented with infection

Post-operative period	Cases	Rate (per 100 surgeries)
Less than one week	12	14.8
One week to one month	20	24.6
One to six months	22	27.1
6-12 months	10	12.3
>12 months	17	20.9

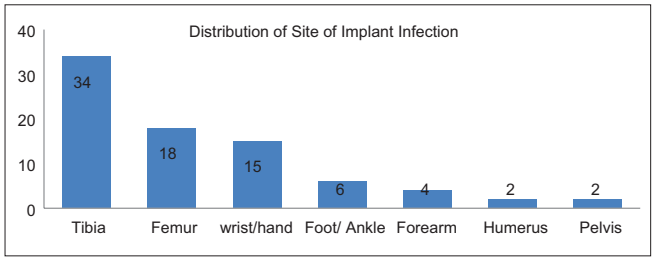

Figure 1: Sites of orthopaedic implanted getting infected

Majority of the patients were in the adult age group and the most common site affected was tibia. These findings can be attributed to the fact that majority of the cases included in this study were road traffic accidents. The post-operative period up to one year is to be screened for SSI if the implant is *in situ*, by assessing the wound healing and any discharge or signs of inflammation at the site, according to the Centers for Disease Control and Prevention (CDC) guidelines. In this study, 79% (64/81) of the cases were within one year of implant surgery. To reduce the implant infection, use of novel implants with surface characteristics to resist biofilm formation has proven effective. In this study, we observed the length of stay in the hospital in these OAI patients to assess the financial burden on the patient. *A. baumannii* was identified to be the pathogen causing a maximum number of days of hospital stay (average 20 days) because these strains were multidrug-resistant superbugs and needed higher antibiotics such as intravenous colistin.

The major external risk factors influencing the successful implant surgeries include the bacterial load in the OR, pre-surgical site preparation and antibiotic prophylaxis. The viable microbes are often released from the surgical team i.e., from the respiratory aerosol and skin scales, which is unavoidable.[11] As per the recommendation,[12] the OR is equipped with high-efficiency particulate air (HEPA) filters, which have 99.97% efficacy and the quality of the air is monitored on a weekly basis with air sampler (Hi-Media Inc., Mumbai) and the HEPA filters are cleaned every six months. The surgical site is prepared with appropriate antiseptic solutions before the surgery, and the pre-surgical antibiotic prophylaxis policy is placed and is followed accordingly. Hence, the external factors contributing to SSI in implant surgeries were strictly monitored to reduce the rate of infection.

The source of the infection can be the patient skin flora or the exogenous factors from the environment in post-operative period. Hence, the proper skin preparation and proper sterilisation and disinfection need to be monitored. The role of hand hygiene plays a very important role in the prevention of SSI. Although the rate of OAIs is less, its morbidity is high and the quality of life is greatly affected. Hence, from microbiological aspect, antibiogram of these pathogens can help in better approach towards empirical treatment and outcome.

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Conflicts of interest

There are no conflicts of interest.

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