RESEARCH ARTICLE

Staphylococcus aureus Colonization in Patients Undergoing Total Hip or Knee Arthroplasty and Cost-effectiveness of Decolonization Programme

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Abstract

Background: Periprosthetic joint infection is a devastating complication of total joint arthroplasty. It seems that the patient's skin, nose, throat, and urine are important sites for microbial colonization. Colonization with staphylococcus aureus, especially methicillin resistant increases the risk of periprosthetic joint infection. The aim of this study was to assess the prevalence of staphylococcus aureus colonization in patients candidate for arthroplasty in central Iran as well as cost-effectiveness of decolonization program for prevention of post-arthroplasty infection.

Methods: A total of 226 patient candidates for total joint arthroplasty were enrolled in this prospective cross-sectional study between January 2014 and January 2016. Specimens from nose, throat, groin skin, and urine were sent for bacteriologic culture and sensitivity test. Analysis cost-effectiveness was then performed for decolonization programme.

Results: Patients had positive cultures from nose (15.9%), throat (4.4%), groin skin (3.1%), and urine (0.9%). In general, 20.8% of the patients had positive cultures for staphylococcus aureus, among whom, 1.8% were methicillin resistant. Based on cost-effectiveness analysis, decolonization program leads to 80% reduction in costs.

Conclusion: According to our results, although colonization with methicillin sensitive staphylococcus aureus in patients undergoing hip or knee arthroplasty is lower than other studies but colonization with methicillin resistant staphylococcus aureus is similar to others. Also, decolonization programme in these patients was found to be very cost-effective.

Level of evidence: II

Keywords: Decolonization, Periprosthetic joint infection, Staphylococcus aureus, Total hip arthroplasty, Total knee arthroplasty

Introduction

Total joint arthroplasty (TJA) is one of the most successful procedures in orthopaedics; however, it may be associated with many complications including periprosthetic joint infection (PJI) (1). Staphylococcus aureus and epidermis are the main causes of infection after arthroplasty (2). Recent studies have shown that the rate of infections by methicillin-resistant staphylococcus aureus (MRSA) has increased from 27% in 1999 to 62% in 2006 (3). Staphylococcus aureus colonization can lead to the introduction of serious and potentially fatal infections in hospitals. In recent decades, orthopedic surgeons have encountered an increased antibiotic resistance simultaneously with increasing use of antibiotics, rising of complicated

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surgical procedures and the reduced lives of patients with immunodeficiency.

The prevalence of MRSA colonization in different patient populations has been reported as 0.18-7.2% with a nosocomial prevalence of 1.7% (4-8). Resistant organism colonization is not only associated with increased risk of infection, but also in 30% of cases, the infection leads to hospital readmission (9, 10). It has been hypothesized that skin, nose, throat, and urine are important centers of infection and bacterial colonization. A third of the patients in the United States in 2001 were colonized with staphylococcus aureus (11). In 2004, the proportion fell to 28%, while the prevalence of MRSA in the same period increased from 0.8% to 1.5% (12). Colonization with MRSA, in particular, increases the risk of postoperative infection (13). Post-TJA infection is a debilitating complication that puts a heavy burden on patients and health services. Many studies have shown that staphylococcus decolonization decreases the risk of PJI (14). The risk of PJI in patients undergoing arthroplasty has been reported between 1-7% (15). The purpose of this prospective study was to determine the prevalence of staphylococcus aureus colonization as well as its antibiotic susceptibility in central Iran, and to evaluate the cost-effectiveness of decolonization program.

Materials and Methods

Patient candidates for hip or knee arthroplasty in vali-asr hospital, Arak city, between January 2014 and January 2016, were enrolled in this descriptive study through convenience sampling. The inclusion criteria were: no symptomatic nose, throat, urine, and skin infections, while, patients with remote source of ongoing infection, recurrent urinary tract infection, and neuropathic arthropathy were excluded from the study. The research group adhered to the principles of medical ethics introduced by the Iranian Ministry of Health; the directives of the Declaration of Helsinki; and the Ethics Committee of the Arak University of Medical Sciences throughout the course of the study. The patients were enrolled with their complete consent and no compulsion. Patients' personal information were kept confidential. The sample size was calculated using the following formula:

Equation 1

$$n = \frac{(P(1-P))\left(Z_{1-\frac{\alpha}{2}}\right)^2}{d^2} = 200$$

Demographic data (including information including the education level, site of living, employment status, hospitalization in recent year, and immunocompromised previous illness) were collected. The urine specimen as well as swabs from the groin skin, nose, and throat of each patient were taken and sent for culture. Culture results were analysed for the presence of staphylococcus aureus and bacterial resistance. Patients with positive cultures were treated with proper antibiotics (Mupirocin ointment for nasal colonization, chlorhexidine solution for body wash, and oral medication for urinary tract infections). Then once again, the samples were taken from the sites that had been previously reported as infected and the results were registered. The aim was to determine the proportion of patients colonized with germs in their bodies and to determine the percentage of methicillin-resistant cases and their antibiotic sensitivity pattern. The cost of decolonization (including visits before surgery, preoperative laboratory testing, treatment for patients with positive culture, and performing cultures again) was calculated and recorded in a checklist. Data analysis was done using SPSS-19. The mean indices, standard deviation, standard error, and frequency were used in the analysis of the results. Covariance analysis, paired test, chi-square test, independent T-test or their non-parametric equivalents were used to compare the means whenever necessary.

Results

A total of 226 patients including 57 males (25.2%) and 169 women (74.8%) were enrolled in this prospective descriptive study. The mean age of the patients was 66.3 (±9.11) years. The mean patients age among the candidates for knee and hip arthroplasty was 67.43 (±7.8) and 66.55 (±11.2) years, respectively. Among patients of this study, 80.4% were candidates for knee arthroplasty and 19.6% for hip arthroplasty. As most patients admitted for hip and knee arthroplasty were old, more than 95% of them were unemployed; 0.9% were farmers; 1.3 %were self-employed; and 0.4 % were construction workers. Only 1.3 of the patients were literate and the rest were illiterate. In this study, 78.5% of respondents were living in the city and the rest (21.5%) lived in rural areas. Overall, 22.6% of the patients who were undergoing hip and knee arthroplasty had particular diseases, 22.1% had a history of drug use, and 15% had a history of hospitalization in the past year.

The rates of colonization with staphylococcus are summarized in Table 1. In general, 47 patients (20.8%) had positive culture results for staphylococcus aureus. Of these, 43 (19%) were sensitive to methicillin sensitive staphylococcus aureus (MSSA) and four patients one point eight percent (1.8%) were methicillin-resistant (MRSA).

A total of 226 cultures were considered for evaluation of the presence of bacteria in the groin skin, nose, pharynx, and urine before the total hip and knee arthroplasty procedure, among whom 47 cases (20.8%) were

Table 1. The prevalence of staphylococcus aureus colonization in different sites of the body

Colonized site	Prevalence
Nose	36 (15.9%)
Pharynx	10 (4.4%)
Groin skin	7 (3.1%)
Urine	2 (0.9%)

Table 2. The costs of tests and decolonization for a hundred patients

	Number of patients	Number of positive culture	Cost for a single patient	Total cost	Sum of costs
Microbial culture test	100		$22.5	$2,250	$2,770
Decolonization		20.8	$25	$520	

Table 3. MSSA and MRSA prevalence in different countries

Author/year	Country	Patient population	Number of patients	MSSA Prevalence	CA- MRSA Prevalence	HA-MRSA Prevalence
Hadi et al(2017)	Iran(Arak)	Patients candidate for arthroplasty	226	19%	1.8%	Not reported
Mousavi-Fard et al(2012) (37)	Iran(Arak)	Students society	813	20.8%	Not reported	Not reported
Jae hoon song et al(2011)(38)	India	General population	136	Not reported	4.3%	22.6%
Berthelot et al(2010)(39)	France	Orthopedic outpatients	3908	20.2%	0.6%	Not reported
Yano et al(2009)(8)	Japan	Orthopedic outpatients	2423	Not reported	2.6%	Not reported
Gorwitz et al(2008)(7)	Multiple sites in US	General population	9004	28.7%	1.5%	Not reported
Price et al(2008)(40)	Western US	Orthopedic outpatients	284	28.5%	1.8%	Not reported
Mertz et al(2007)(41)	Switzerland	Inpatients, health-care workers, and blood donors	2966	36.5%	0.6%	Not reported
Kenner et.al(2003)(42)	Hawaii	General population	404	38%	2%	Not reported
Wertheim et.al(2004)(43)	Netherland	Orthopedic outpatients	9859	Not reported	0.03%	Not reported
Alghaity et.al (2000)(44)	Saudi Arabia	Community and inpatients	1999	Not reported	1.3%	4.7%

reported positive. The tariff to perform culture tests for each patient was $22.5. Pre-operation decolonization cost for each patient (including the medication, one additional visit, retesting, and commuting) was considered as $25 [Table 2]. The cost of treating a patient suffering from PJA after arthroplasty was estimated at about $20,000. According to previous studies, the decolonization programme reduces the risk of infection with staphylococcus aureus by 30–50 % (16-19). To determine the cost-effectiveness of decolonization before surgery, the total consumer spending was divided by the total number of positive cases detected. With regard to the 2-7% prevalence of infection after arthroplasty, if the programme reduces only one infection out of a hundred patients, cost-effectiveness evaluation would be as follows:

$20,000 – $2,770 = $17,230

Therefore, performing the decolonization programme produces around an 80% reduction in costs.

Discussion

In this study, the decolonization programme of staphylococcus aureus in patients undergoing hip and knee arthroplasty was evaluated. The colonization rate with Staphylococcus aureus and MRSA acquired from the community were 20.8% and 1.8%, respectively, which are compatible with figures obtained in other areas. Japoni-Nejad showed that the rate of colonization with staphylococcus aureus in healthy Iranian school children was 19%, which is very close to our results and the results from other studies. The prevalence of community acquired MRSA (CA-MRSA) was estimated to be 1% lower than our result (20, 21). Despite the increase in the infection rate across the world, the incidence of MRSA in healthy people remains low in several parts. The consolidated data from ten studies (8350 patients) showed MRSA prevalence as 3.1%. After the elimination of risk factors, the rate fell to 2%. MRSA accounted for 25.5% of the total isolates of community acquired (CA) staphylococcus aureus infections, whereas 67.4% of hospital associated (HA) infections were caused by MRSA (22).

Descriptive studies have suggested that the colonization rate in the general population varies worldwide, with MSSA nasal carriers making up to 8%-20.8% of the population, and MRSA nasal colonization composing 0.6-38.8% of the population .The prevalence of nasal carriage of MSSA and MRSA in various geographic regions is summarized in Table 3.

We recorded that colonization with MSSA in patients undergoing hip or knee arthroplasty was lower than other studies but colonization with MRSA is similar to others.

These differences may be due to the sampling conditions and sites and sizes, the inclusion and exclusion criteria, or genetic predisposition. It is not clear whether the risk

factors associated with colonization with CA-MRSA in different societies are alike or different (23) . This shows the importance of reviewing the risk factors separately in different societies. Molecular laboratory techniques have showed that infection mostly contains the same strain of MRSA that caused nasal colonization; therefore, determination of the prevalence of staphylococcus aureus colonization could be helpful in predicting the likelihood of infections caused by MRSA (11). There are sizable differences in the prevalence of nasal CA-MRSA colonization in different parts of the world. Data analysis of 26 countries in the "European Antimicrobial Resistance Surveillance Network (EARS-Net)" carried out between 1999 and 2002 revealed that the rate of resistance to MRSA in the samples extracted from blood were less than 1% in northern Europe and 40% in southern and western Europe (24). In our study population, 75% of the participants were women; however, no significant relationship was found between gender and the colonization of CA-MRSA (25). Some studies have shown that CA-MRSA infection and colonization are more common in young people; other studies have contrarily claimed that it is more common in older people (26-30). Some studies have rejected aging as a risk factor for contracting hospital acquired MRSA. However, the relationship between colonization with CA-MRSA and age was not significant according to our results. Some occupations, such as military service or professional athletics possess a higher risk of infection or colonization with CA-MRSA (26, 28, 31, 32). In another study, the related activities of health centres has been deduced as a risk factor for colonization with CA-MRSA (33). In this study, 38 people were working in different fields, but no significant association between the colonization with CA-MRSA and their jobs was detected. The results of studies on the correlation between hospital admission and MRSA are controversial. Some authors believe that the recent history of hospitalization is a risk factor for infection with HA-MRSA, while others believe in such a relationship for CA-MRSA (23, 30, 34-36). Recent reception of health services in Taiwan has been associated with higher rates of colonization with MRSAs resistant to multiple antibiotics (37). At the same time, some authors believe that there is no relationship between the colonization with CA-MRSA and hospitalization, and they argue that admission during the past year should not exclude the possibility of infection or colonization with CA-MRSA (27, 38). This could be due to differences in definitions used to describe MRSA-CA and HA-MRSA. This study showed no relationship between hospitalization in the last year and colonization of CA-MRSA. Sousa Rj and colleagues showed that there is no benefit in screening and pre-operative decolonization of staphylococcus aureus carriers. Infections in hospitalized patients colonized with MRSA have increased as high as 36±11% (5, 39). It has been reported that the cost of serious infections is significantly greater with MRSA and results in more prolonged hospitalizations in comparison to MSSA infections(40). Based on the results of the recently published meta-analysis, MRSA compared to MSSA bacteraemia, researchers have concluded that appropriate antibiotic independently and significantly helps reduce the risk of death (41). Rapid diagnosis with the use of colonization test, using timely precautionary communication measures and future regulations, is of vital importance for successful control of MRSA, especially in patients undergoing hip and knee arthroplasty (42).

A case-control study compared 19 adult patients with Staphylococcus aureus bacteraemia with 19 control people matched in terms of early diagnosis, the number of secondary diagnoses, age, gender, and hospital ward. This study estimated extra costs attributable to bacteraemia; these included $27,083 for patients with MRSA and $9,661 for MSSA. The results showed that the extra cost is estimated at 17,422 due to a blood infection contracted at the hospital (43). Based on the results it was expected that decolonization would reduce the rate of postoperative infection down to 30-50% (16). It has been reported that about 2% of arthroplasty surgeries led to infection. If this method of removing microbes before surgery reduced the infection in a single patient in a group of 100 patients, the cost of treating postoperative infections in these patients ($20,000) would have to be compared with the cost of decolonization in 100 patients. Based on the results of this study, performing decolonization programme results in approximately 80% reduction in costs.

According to the results of this study, although colonization with MSSA in patients undergoing hip or knee arthroplasty is lower than other studies; however, colonization with MRSA is similar to others. According to the cost-effectiveness analysis of this project, carrying out the decolonization programme in patients undergoing TJA is not only very cost-effective, but also helps physicians choose the appropriate antibiotics and hospital epidemiologists to identify the right policies to control nosocomial infections.

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