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Prevalence of Nasal Carriage of Methicillin-Sensitive and Methicillin-Resistant *Staphylococcus aureus* in Candidates for Total Hip or Knee Arthroplasty

Prevalencia de portación nasal de Staphylococcus aureus sensible y resistente a la meticilina en candidatos a artroplastia total de cadera o rodilla

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Abstract

Introduction Surgical-site infections in joint replacement surgery are an important source of morbidity and mortality that entail high economic and social burden both for the patient and their environment. Preoperative colonization by *Staphylococcus aureus* has been recognized as an important risk factor for the development of surgical-site infection.

The aim of the present study is to determine the prevalence of nasal colonization by *S. aureus*, both methicillin-sensitive (MSSA) and methicillin-resistant (MRSA) in patients who are candidates for total replacement of the hip or knee joints.

Materials and methods A retrospective observational study of a cohort of 646 patients with an indication to undergo total hip arthroplasty (THA) or total knee arthroplasty (TKA) due to severe osteoarthritis was performed in a Public Hospital in Chile. The patients were submitted to a preoperative screening for *S. aureus* carriage, and the culture samples were obtained by swabbing both nostrils. The laboratory data was collected and presented as a percentage of carriage.

Results We consecutively examined 303 THA and 343 TKA patients. A total of 483 of the 646 patients (74.7%) underwent a preoperative study of nasal carriage. We

Keywords
- hip replacement
- knee replacement
- preoperative screening
- Staphylococcus aureus
- decolonization

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identified 123 (25.4%) *S. aureus* carriers, and only found 2 (0.41%) cases corresponding to MRSA.

Conclusion We found a prevalence of nasal carriage of *S. aureus* of 25.4%, a rate similar to that reported in other series. The prevalence of MRSA (0.41%), however, was lower than that reported in the international literature (0.6–6%). Given the high prevalence of carriage described in our work and according to recently published data, it would be worthwhile to carry out universal decolonization protocols, without the need for preoperative screening.

Resumen

Introducción Las infecciones perioperatorias en cirugía de reemplazo articular son fuente importante de morbimortalidad, así como de altos costos económicos y sociales, tanto para el paciente como para su entorno. La colonización preoperatoria por *Staphylococcus aureus* ha sido reconocida como un factor de riesgo importante para desarrollar una infección de sitio quirúrgico.

El objetivo de este estudio es conocer la prevalencia de portación nasal de *S. aureus*, tanto sensible a la meticilina (SASM) como resistente a la meticilina (SARM), en pacientes candidatos a cirugía de reemplazo articular de cadera o rodilla.

Materiales y métodos Se realizó un estudio observacional de una cohorte retrospectiva de pacientes con indicación de artroplastia total de cadera (ATC) y rodilla (ATR) electiva por artrosis severa en un hospital público de Chile. Los pacientes fueron sometidos a tamizaje preoperatorio de portación, cultivándose muestras obtenidas mediante hisopado de ambas fosas nasales. Los datos del laboratorio fueron recopilados y presentados como porcentaje de portación de *S. aureus*.

Resultados Se estudiaron 303 pacientes consecutivos de ATC y 343 de ATR. En total, 483 de los 646 pacientes (74,7%) tuvieron estudio preoperatorio de portación nasal. Se identificaron 123 pacientes (25,4%) portadores de *S. aureus*, de los cuales sólo 2 (0,41%) casos correspondieron a SARM.

Conclusión La prevalencia de portación nasal de *S. aureus* obtenida fue de 25%, similar a lo reportado en otras series. La prevalencia de SARM (0.41%), sin embargo, estuvo bajo lo descrito en la literatura internacional (0,6–6%). Sería de utilidad, dada la alta prevalencia de portación descrita en nuestro trabajo y de acuerdo a evidencia publicada recientemente, realizar protocolos de descolonización universales, sin necesidad de realizar tamizaje preoperatorio.

Palabras Clave
- prótesis total de cadera
- prótesis total de rodilla
- tamizaje preoperatorio
- Staphylococcus aureus
- decolonización

Introduction

Joint replacement surgery (JRS) is one of the most successful procedures in traumatology, with 80% to 90% of good clinical outcomes,[1] and it relieves pain and improves the quality of life of many patients. Total hip arthroplasty (THA) is the surgery of the century due to its significant impact on the functionality of patients.[2]

In recent years, the number of JRSs, either THA or total knee arthroplasty (TKA), has experienced a steady rise, and the international literature suggests that this increase will persist. In 2010, 332 thousand THAs and 719 thousand TKAs were performed in the United States, and these figures should double by 2030.[3] Similarly, from 2013 to 2030, Australia expects increases of 276% and 208% in TKAs and THAs respectively.[4]

The Chilean Department of Statistics and Health Information (Departamento de Estadísticas e Información en Salud, DEIS, in Spanish)[5] reported 5,312 THAs and 2,619 TKAs due to arthrosis in 2012. In 2018, the number of elective surgeries rose to 8,231 THAs and 5,276 TKAs, representing increases of 54.95% and 101.45% respectively. Likewise, according to a recent Chilean report,[6] hip fracture, a condition expected to cause 9,862 cases per year by 2030, will also be a significant source of candidates for hip arthroplasty.

An increase in joint replacements will cause and increase in the number of complications, including periprosthetic infection (PPI), which are associated with high morbidity, mortality, hospital stay, and healthcare costs.[7]

Several risk factors influence the development of PPI.[8–10] While some risk factors are patient-related (such as obesity, diabetes mellitus, rheumatoid arthritis, smoking etc.), others depend on the procedure per se (duration, soft-tissue damage, the surgical volume of the surgeon etc.). In recent years, *Staphylococcus aureus* carriage was recognized as a factor to consider in the development of nosocomial infection. This

microorganism reportedly increases the risk of infection in numerous clinical scenarios, and the high concordance of nasal and surgical site culture results indicates a significant endogenous route of contamination.

In Chile,[11] the reported incidence of surgical wound infections (SWIs) in hip prostheses is of 1.83%. Of those with an identified etiological agent (60.5%), 39.5% were secondary to *S. aureus*, followed by *Klebsiella pneumoniae* (13.9%), *Pseudomonas aeruginosa* (11.6%), and *Staphylococcus epidermidis* (6.9%). The international literature cites *S. aureus* and *S. epidermidis* as causes of 50% to 60% of hip and knee periprosthetic infections.[12–14]

A critical issue is the growing resistance of microorganisms to antimicrobials, which has been reported worlwide.[15,16] According to the Ministry of Health of Chile,[11] the rate of resistance of *S. aureus* resistance to oxacillin (methicillin) was o 33.5% from 1991 to 1993, and it reached 63.3% from 2008 to 2010.

The international literature reports that 20 to 30% of the population presents permanent colonization by *S. aureus*, and that a similar percentage has transient colonization.[17,18] However, there is little information regarding carriage in the Chilean population.

Although international consensuses[19] guide the prevention, diagnosis, and management of PPIs, the epidemiology of each region or center must guide local strategies. Therefore, knowing the prevalence of methicillin-sensitive and methicillin-resistant *S. aureus* (MSSA and MRSA respectively) carriage before elective JRSs would help in the development of local screening guidelines, antibiotic prophylaxis regimens, and, eventually, preoperative decolonization protocols.

The present study aims to determine the prevalence of the nasal carriage of *S. aureus*, either MSSA or MRSA, in candidates for elective hip and knee JRS in a tertiary healthcare center.

Materials and Methods

The institutional ethics committee authorized access to the database of operated patients and laboratory results.

The present cross-sectional observational study included patients undergoing THA or TKA from January 2017 to March 2018 in a public hospital in the Metropolitan Region of Santiago, Chile. Hip fractures or revisions of previous surgeries were excluded. We reviewed the laboratory results available in the clinical record system, adding the age and gender of each patient. Clinical data such as weight, height, comorbidities, and recent hospitalizations were not available due to issues in accessing charts and the scarcity of records.

We calculated the required sample size based on the prevalence reported in other studies (ranging from 25% to 30%) as a minimum of 232 patients.[20] The treating physician requested the carriage examination on an outpatient basis along with other preoperative tests 0 to 6 months before surgery. The screening strategy was universal, so we did not consider historical findings to determine whether to carry out the study or not.

Sample obtention followed a standardized technique,[18] in which we insert a sterile swab, previously moistened with saline solution, 2 cm to 3 cm into each nostril of the patient until it stops, usually in the nasal turbinate, and rotate each swab 360°. The samples arrived at the laboratory within 24 hours. Incubation at 35°C for up to 72 hours was performed in 3 culture media: blood agar, chocolate agar, and McConkey agar. Pathogen identification followed the protocols of the microbiology laboratory. The minimum inhibitory concentration (MIC) determined the susceptibility to oxacillin per dilution in agar, as defined by the Clinical & Laboratory Standards Institute (CLSI).[21]

Patients positive for *S. aureus* underwent treatment with topical 2% mupirocin (cream) in each nostril every 12 hours for 5 days. Patients with MRSA received vancomycin in addition to mupirocin as perioperative antibiotic prophylaxis. No control culture was requested from the treated patients.

As for the statistical analysis, the results were reported as mean and standard deviation (SD) or median and range values as appropriate. The categorical vairables were expressed as absolute and relative frequencies. The analysis was performed using Excel (Microsoft Corp., Redmond, WA, United States).

Results

A total of 303 THAs and 343 TKAs were performed during the study period. Of the 646 patients, 483 (74.7%) had a preoperative nasal carriage examination whose results were recorded and analyzed.

Female patients comprised 54% (261) of the sample, whose mean age was of 71.3 years (SD: $\pm$ 7.8). Of the 483 patients studied, 123 (25.4%) had a positive *S. aureus* culture, and only 2 patients (0.41%) carried MRSA.

The mean age of *S. aureus*-positive patients was 69.1 years (SD: $\pm$ 5), and 53% (65) of them were female. For non-carriers, the mean age was 71 years (SD: $\pm$ 8.04), and 51% (183) of them were female.

In the THA cohort (303), 80.5% (244) of the patients had a preoperative examination. Of these, 25% (61 patients) were MSSA carriers. No cases of MRSA carriage were observed in this group.

In the TKA group (343), 68.9% (239) of the patients had a preoperative examination. Of these, 25.9% (62 patients) were positive for MSSA, and there were 2 cases (0.83%) of MRSA. ► **Table 1** summarizes these findings.

Discussion

Periprosthetic infections are infrequent complications after primary arthroplasty, with reported incidences ranging from 0.5% to 3%.[22,23] However, they can be catastrophic, with high costs for patients and healthcare systems, increased hospital stays, multiple surgeries, long-term use of antibiotics, and high morbidity and mortality. Multiple risk factors are associated with PPI,[8–10] including *S. aureus* carriage.

Table 1 Prevalence of nasal carriage of MRSA and MSSA according to surgery and gender.

	MSSA	MRSA	No colonization	Total
THA	61 (25%)	0 (0%)	183 (75%)	244
TKA	62 (25.94%)	2 (0.83%)	175 (73.23%)	239
Female gender	67 (25.7%)	0 (0%)	194 (74.3%)	261
Male gender	56 (25.2%)	2 (0.9%)	164 (73.9%)	222
Average age (years)	69.5	71.5	71.7	71.3 ± 7.8

Abbreviations: MSSA, methicillin-sensitive *Staphylococcus aureus*; MRSA, methicillin-resistant *Staphylococcus aureus*; THA, total hip arthroplasty; TKA, total knee arthroplasty.

The present study revealed a nasal carriage rate of *S. aureus* consistent with the rates reported in international series on orthopedic surgery, between 20% and 30%.[17,18,24] However, other authors[25–27] report that the prevalence of MRSA strains ranges from 0.6% to 6%, which is higher than that observed in the present cohort.

There are few Chilean reports on the asymptomatic nasal carriage of *S. aureus*. In 2010, 500 healthy volunteers underwent nasal swabbing before a medical visit. Of the final sample of 454 subjects, 103 (22.7%) were positive for MSSA, and 1 (0.2%) was positive for MRSA,[28] which is consistent with our findings. Recently, Schweitzer et al.[29] published a series of 146 THA patients with nasal and inguinal samples collected on the day of surgery for a molecular study with reverse transcription-polymerase chain reaction (RT-PCR). A total of 7 (5%) cases were positive for MRSA, and the previous use of antibiotics was a risk factor. Only 1 of the 7 positive cases (0.68% of the total sample) was an exclusive nasal carrier. In addition, four of these seven cases were inguinal carriers, and two out of these same seven had the organism in both sites. These findings may suggest a good performance of the study of the inguinal region in the detection of MRSA, but they also show a 2.05% rate of nasal MRSA carriage.

Evidence on the usefulness of the detection and decolonization of MSSA/MRSA carriers remains controversial. Some studies[30–32] have shown it to decrease the rates of SWI and PPI, while others[33,34] have concluded the opposite, revealing an increase in infection by other microorganisms or a lack of risk "normalization" in decolonized carriers versus non-carriers.

A recent metanalysis[35] including 9 studies, 2 of them prospective, and 36,041 arthroplasties revealed that universal carrier screening protocols along with a perioperative bath with chlorhexidine dressings, nasal eradication with mupirocin, and antibiotic therapy adjustment in MRSA carriers resulted in a 57% reduction in SWI rates and a 60% reduction in PPI rates.

The evidence on the cost-effectiveness of universal versus selective screening based on risk factors is mixed. Some authors prefer universal screening[36–38] to avoid excluding patients mistakenly deemed low risk, considering that up to 50% of carriers do not present the risk factors described.[39,40]

However, other studies[41] suggest universal nasal eradication with mupirocin, with no screening. This strategy would be cheaper (saving 35 dollars per patient) and more efficient by reducing administrative errors in test requests and medical visits for the review of results. A recent systematic review and metanalysis[42] on preoperative screening and decolonization to reduce surgical site infections showed an increased risk of general and *S. aureus* infections in non-decolonized patients undergoing general orthopedic procedures, THA, or TKA; the authors concluded that, although all screening-decolonization strategies are cost-effective, universal decolonization with no preoperative screening is the most advantageous protocol.

The present study shows a prevalence of 25.9% of nasal carriage of *S. aureus* in a sample of 483 patients studied, constituting the largest series reported in Chile. In addition, the data are from orthopedic patients alone, with the required sample size according to the reported prevalence. At the same time, as this is a tertiary-level public hospital, we believe that our findings are representative of the community and enable a proper estimate of the actual prevalence of MSSA/MRSA colonization. As the investigation occurred before surgery, we could take specific preoperative and intraoperative measures, including nasal decolonization and antibiotic therapy adjustment, after MRSA detection.

However, the lack of relevant clinical history on body mass index (BMI), comorbidities, and known risk factors for colonization (use of antibiotics, recent hospitalizations, dialysis, venous catheter etc.) challenges carrier characterization and the recognition of local risk factors. Likewise, the lack of follow-up of the patients who underwent the decolonization protocol does not enable the evaluation of outcomes from our intervention or its cost-effectiveness.

Due to the limited availability of institutional resources, one weakness of the present study was using cultures for the detection of microorganisms. Cultures have a reported sensitivity ranging from 66% to 90%, whereas RT-PCRhave 99% to 100% of sensitivity.[25,43,44] This fact may explain the lower prevalence rate of MRSA (0.41%) compared to that of other studies using molecular biology methods and multiple sampling sites, such as the one by Schweitzer et al.,[29] who found a rate of 5%.

In contrast, several authors[45,46] have suggested the simultaneous study of other anatomical sites not included here (such as the inguinal region and the pharynx) using culture methods, which could increase the yield but not the costs, which is not true when using RT-PCR.

Although the present work only enables the determination of carriage prevalence at a local level, its importance lies

in the recognition of the national context to design IPP prevention protocols and prospective long-term studies to assess the impact of the prevention measures adopted.

Conclusions

The nasal carriage of MSSA in the studied patients is consistent with the reports in the national and international literatures. However, the prevalence of MRSA was lower than that described by several authors.

Future prospective studies could define the cost-effectiveness of this measure as another tool to reduce the burden and costs associated with surgical site infections in a group of patients that will continue to increase due to the greater life expectancy of the population.

Recommendations

Based on our findings, which are consistent with those of previous reports, and the recently published literature,[42] we recommend universal decolonization protocols with no preoperative screening in patients undergoing elective hip or knee arthroplasty.

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Conflict of Interests
The authors have no conflict of interests to declare.

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