Journal of Infection ■■ (2018) ■■–■■

Contents lists available at ScienceDirect

Journal of Infection

journal homepage: www.elsevierhealth.com/journals/jinf

Analysis of postoperative and hematogenous prosthetic joint-infection microbiological patterns in a large cohort

Valérie Zeller [a,b,*], Younes Kerroumi [b], Vanina Meyssonnier [a,b], Beate Heym [b,c], Marie-Astrid Metten [d], Nicole Desplaces [b,c], Simon Marmor [b,e]

[a] Service de Médecine Interne et Rhumatologie, Groupe Hospitalier Diaconesses–Croix Saint-Simon, 125, rue d'Avron, Paris 75020, France
[b] Centre de Référence des Infections Ostéo-Articulaires Complexes, Groupe Hospitalier Diaconesses–Croix Saint-Simon, 125, rue d'Avron, Paris 75020, France
[c] Laboratoire des Centres de Santé et Hôpitaux d'Ile-de-France, Groupe Hospitalier Diaconesses–Croix Saint-Simon, 125, rue d'Avron, Paris 75020, France
[d] Service de Recherche Clinique, Fondation Ophtalmologique Adolphe de Rothschild, Paris 75019, France
[e] Service de Chirurgie Osseuse et Traumatologique, Groupe Hospitalier Diaconesses–Croix Saint-Simon, 125, rue d'Avron, Paris 75020, France

ARTICLE INFO

Article history:
Accepted 11 December 2017
Available online

Keywords:
Microbiology
Prosthetic joint infection
Hematogenous

ABSTRACT

Objectives: This study was undertaken to analyze prosthetic joint infection (PJI)-causing microorganisms and compare their distribution patterns according to PJI classification.
Methods: Cohort study from a single referral center for bone-and-joint infections from January 2004 to December 2015.
Results: Nine hundred and twenty-six patients, who developed 997 PJIs, involving the hip (62%), knee (35%) and/or shoulder (1%), were included. PJIs were classified as early postoperative (19%), late chronic (30%), hematogenous (35%) and undetermined (16%). Pathogens most frequently isolated from early-postoperative PJIs were staphylococci (57%), with 25% each *Staphylococcus aureus* or *Staphylococcus epidermidis*; 21% were polymicrobial and 10% Gram-negative rods. For late-chronic PJIs, the most frequent microbes were staphylococci (61%), predominantly *S. epidermidis* (35%); anaerobic bacteria were isolated from 15%; 11% were polymicrobial. Hematogenous PJIs were 99% monomicrobial. Although *S. aureus* was the most frequently isolated species (28%), streptococci were isolated slightly more often than staphylococci (39% vs. 36%). Among streptococci, group B streptococci were the most frequent (15%). The portal of entry was identified for 52% of hematogenous PJIs: 15% cutaneous, 11% dental, 9% gastrointestinal, 6% urinary, and 11% miscellaneous.
Conclusion: Although a wide variety of microorganisms was isolated from PJIs, specific microbiological patterns were observed according to infection classification.

Background

Joint arthroplasty can be a highly effective intervention to improve the quality of life of patients with joint damage by relieving pain and restoring joint function. Albeit rare, prosthetic joint infection (PJI) is certainly one of the most devastating complications of arthroplasty, with serious medical and psychological consequences for the patient, and a high economic burden for society. PJI management remains difficult and a multidisciplinary approach is essential to achieving therapeutic success.[1,2]

The first step for optimal treatment is the precise identification of the involved microorganism(s) and its(their) antimicrobial-susceptibility testing. A wide range of pathogens with different susceptibility profiles are responsible for PJIs, even though staphylococci are the most frequently isolated bacterial genus. Moreover, the microbiological distributions of these infection-causing microbes differ according to the study population's epidemiological and geographical characteristics, the time to PJI onset after the last clean operation, clinical local and general PJI signs and its pathogenesis. Briefly, PJIs have been classified as postoperative, occurring early during the first month postsurgery or later, or defined as hematogenous, e.g., arising from a distant source.[3,4]

The objectives of this study were to analyze the microorganisms isolated from a large cohort of PJIs managed at a French referral center for bone-and-joint infections and compare their distribution patterns according to infection classification.

* Corresponding author. Centre de Référence des Infections Ostéo-Articulaires Complexes, Groupe Hospitalier Diaconesses–Croix Saint-Simon, 125, rue d'Avron, Paris 75020, France.
E-mail address: vzeller@hopital-dcss.org (V. Zeller).

https://doi.org/10.1016/j.jinf.2017.12.016
0163-4453/

Methods

Study design and population

We conducted a retrospective analysis of data prospectively collected from our PJI cohort (NCT 019635, NCT 02801253) between September 1, 2004, and December 31, 2015. Patients were included if they were ≥18 years old and had a PJI as defined below. Patients with supposed aseptic loosening and negative preoperative joint-aspirate cultures, but positive intraoperative sample cultures, were not included.

The following information was collected from the center's prospective database: age, sex, infection classification, previous surgical and medical treatments of the ongoing PJI, PJI duration before treatment in our center and the microorganism(s) isolated.

PJI was defined as isolation of the same organism from ≥2 cultures of preoperative joint fluid and/or intraoperative tissue specimens plus ≥1 of the following criteria: a sinus tract communicating with the prosthesis, synovial leukocyte count >1700/mm^3 with a differential of >65% neutrophils and/or clinical (i.e., local inflammatory signs including swelling, warmth, and erythema), laboratory (C-reactive protein >5 mg/L) or radiological signs (i.e., periosteal bone formation, subchondral osteolysis) of infection.

Microbiology

Identification of the microorganism(s) isolated from PJIs relied on results of intraoperative sample and/or joint-fluid–aspirate cultures.

Preoperative joint-fluid aspirates

These aspirates were obtained from all but 30 (3%) patients after discontinuing any concurrent antibiotic therapy for 2–4 weeks. Joint aspiration was done in the Department of Radiology under fluoroscopic guidance and strict sterile conditions. After joint-fluid aspiration, saline was injected into the joint and then recovered. When possible, 2 samples were obtained after saline injection. Specimens were transported within 2 hours to the Microbiology Laboratory, where differential white blood cell counts were determined by light microscopy. Synovial fluid was inoculated onto PolyViteX (PVX) chocolate agar (incubated under 5% CO_2) and anaerobic Columbia agar plates (bioMérieux, Marcy-l'Étoile, France) and into aerobic (Hemoline, bioMérieux) and anaerobic enrichment broths (Schaedler broth, bioMérieux). All cultures were examined daily for 8 days; on day 8, or earlier if bacterial growth was visible, broths were subcultured on PVX chocolate agar and anaerobic Columbia agar plates and incubated at 37 °C for 48 hours. Those culture results were considered to be positive when microorganism(s) grew; when no joint fluid had been collected, culture results were considered positive when ≥2 cultures of the recovered injected saline grew with the same pathogen(s).

Intraoperative sampling

Standardized preoperative hygiene procedures were applied to all patients. Intraoperative samples were taken before starting antibiotics. At least 3 samples of bone and/or synovium that appeared inflamed or infected were collected during surgery. They were processed aseptically within 2 hours in a class-2 laminar air-flow safety hood. Specimens were disrupted by vigorous crushing in sterile mortars with sterile diluents. Aliquots of the resulting suspensions were cultured as described above.

Bacteria were identified to species with the rapid ID 32A kit (bioMérieux) and, since 2012, by mass spectrometry (MALDI biotyper, Bruker Daltoni GmbH, Breme, Germany). Antibiotic-susceptibility testing used the standard disk-diffusion method according to the French Society of Microbiology.[5]

Definition of the involved microorganism(s)

In patients undergoing surgery, the pathogen was considered PJI-causative, when it was isolated from ≥2 different intraoperative specimen samples or joint-fluid aspirates.

For 102 patients not undergoing surgery, because of high surgical risk, PJI diagnosis and pathogen identification were based on joint-aspirate–culture results. The same approach was applied to the 98 patients receiving preoperative antibiotics for clinical sepsis or presence of a virulent microorganism and negative intraoperative sample cultures. Microorganism(s) was(were) considered PJI-causative, when *Staphylococcus aureus*, streptococci, *Enterococcus faecalis*, Enterobacteriaceae or *Pseudomonas aeruginosa* grew in joint-fluid cultures with the following criteria: >1700 leukocytes/mm^3, with >65% neutrophils in the synovial fluid, and a sinus tract communicating with the prosthesis, and/or local, biological and radiological signs of PJI. If a commensal bacterium was isolated (coagulase-negative staphylococci, *Propionibacterium acnes*. . .), another joint aspirate was obtained. The microorganism was considered PJI-causative, if isolated twice.

We classified microorganisms according to genus. Polymicrobial infections included different genera. Mixed staphylococcal PJIs were defined as having different staphylococcal species present.

Infection classification

Three clinical settings based on initial PJI signs, derived from Tsukuyama's classification,[3] were defined, analyzed and compared: early postoperative, late chronic and hematogenous.

Two PJI groups were considered postoperatively acquired, i.e., without signs of hematogenous spread. Early-postoperative infection was defined as surgical site pain, redness with or without drainage, associated or not with fever, occurring within 30 days after joint arthroplasty. Late-chronic infection was defined as progressive pain, joint dysfunction with or without a fistula, occurring ≥1 month after joint arthroplasty.

A hematogenous infection was defined as occurring after a symptom-free interval of ≥1-month postsurgery, with sudden onset of pain, joint dysfunction with or without fever, and/or chills, a virulent bacterium compatible with hematogenous dissemination (*S. aureus*, *Streptococcus*, Enterobacteriaceae. . .), or identification of a portal of entry (e.g., *Staphylococcus epidermidis* PJI spreading from an indwelling venous access device infected with the same microorganism). The portal for these hematogenous PJIs was sought by analyzing of the patient's history (report of a remote infection preceding PJI), physical examination and, if necessary, additional complementary investigations. The origin was defined as microbiologically confirmed, when cultures of samples from the suspected source yielded the same microorganism as that isolated from infected-joint–sample cultures. Rectal and genital swabs were systematically obtained from patients with group B streptococcal PJIs, even those asymptomatic, to search for this bacterium. If swab cultures were positive, we considered colonization to be the infection source. The portal of entry was defined as presumed, if anamnestic and/or physical examination found a distant infection source compatible with the identified microorganism (e.g., dental infection in a patient with *Streptococcus mitis/oralis* PJI).

Clinical settings not meeting those definitions were classified as undetermined.

Concomitant multiple joint-arthroplasty infections were defined as ≥2 PJIs due to the same microorganism during the same septic episode.

Successive multiple joint-arthroplasty infections were defined as ≥2 PJIs yielding different microbes and occurring at different times.