

# Assessment of the species diversity of microorganisms and methods of surgical correction for periprosthetic infection of the hip and knee joints

## Abstract

The article describes the species composition of pathogens and methods of surgical treatment in 85 patients with periprosthetic infection (PPI) of the hip and knee joints. Among all pathogens of PPI, *Staphylococcus aureus* was isolated in 56.5%. Representatives of gram-negative anaerobic microflora are represented by isolates (*Acinetobacter baumannii*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*) in 43.5%. In the treatment of patients with infection of the prosthetic hip and knee joints, the most effective surgical method is used in 69.4% of cases.

**Keywords:** periprosthetic infection, microorganism, surgical treatment

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Ivantsou UA,<sup>1</sup> Garpushkin EA,<sup>2</sup> Todrik AT,<sup>2</sup> Ivantsou AU,<sup>3</sup> Tsydzik IS<sup>4</sup>

<sup>1</sup>Department of Traumatology, Orthopedics and Military Field Surgery, Grodno State Medical University, Republic of Belarus

<sup>2</sup>Healthcare Institution, City Clinical Hospital of Emergency Medicine of Grodno, Republic of Belarus

<sup>3</sup>Department of Normal Anatomy, Grodno State Medical University, Republic of Belarus

<sup>4</sup>Grodno Regional Clinical Cardiology Center, Republic of Belarus

**Correspondence:** Ivantsou UA, Department of Traumatology, Orthopedics and Military Field Surgery, Grodno State Medical University, Republic of Belarus, Email [ivantov.mail.by@mail.ru](mailto:ivantov.mail.by@mail.ru)

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## Introduction

PPI is one of the most formidable complications of arthroplasty of large joints. The incidence of infectious complications in prosthetics of the hip and knee joints, according to various authors, is 2–4%,<sup>1,2</sup> and in Russia it is 5–6%.<sup>3</sup> This problem has received close attention of national and international scientific medical associations. So, in 2013, the recommendations of the Infection Disease Society of America (IDSA) were published.<sup>4</sup> In this connection, the analysis of infectious complications after hip and knee arthroplasty with the study of the species composition of the pathogens of PPI is relevant.

## Aim of the study

To study the species composition of the causative agents of PPI and to analyze the methods of treatment of PPI after total hip and knee replacement.

## Materials and research methods

The analysis of the results of treatment of 85 patients with PPI after total hip and knee arthroplasty, who were treated in the Healthcare Institution “City Clinical Emergency Hospital of Grodno” in the period from 2014 to 2020. The presence of PPI was based on the presence of the following criteria: two positive results of microbiological examination of biopsy specimens from different localizations with phenotypically identical isolated microorganisms, a functioning fistulous tract communicating with the joint cavity,<sup>5</sup> which are recommended for clinical and scientific research by the Society for the Fight against Musculoskeletal Infections. The study of the causative agents of PPI was carried out in a retrospective analysis of the results of bacteriological examination of the material in 85 patients with PPI after total hip and knee arthroplasty. The material was taken in the operating room or in the dressing room before performing medical and

diagnostic procedures. For the delivery of biological material, sterile transport containers from Heinz Herenz (Germany) were used. The material for bacteriological research was: wound discharge from the area of the infected prosthesis and the fistulous tract. Microbiological studies were carried out in the microbiological laboratory of the State Institution “Grodno Regional Center for Hygiene, Epidemiology and Public Health”. Sowing, cultivation, identification and determination of antibacterial sensitivity were carried out in accordance with the current instructions of the Ministry of Health of the Republic of Belarus.<sup>6</sup> Sowing was performed on blood agar, yolk-salt agar, Endo medium, Sabouraud medium. The inoculations were cultivated: blood agar at 35–37°C, 5–10% CO<sub>2</sub> for 24–48 hours; Endo environment - at 35–37°C under aerobic conditions for 24 hours; yolk-salt agar - at 35–37°C under aerobic conditions for 24–48 hours; Sabouraud’s environment - at 25–30°C under aerobic conditions for 72 hours. When growth appeared on solid nutrient media, the colonies of microorganisms grown on the plates were counted and their species identification was carried out using classical methods or using a semi-automatic microbiological analyzer ATB - expression and Vitek - L compact 30. The sensitivity of the isolates of microorganisms was determined according to the instruction of the Ministry of Health of the Republic of Belarus “Methods for determining the sensitivity of microorganisms to antibacterial drugs” by the disk-diffusion method or using a semi-automatic microbiological analyzer ATB - expression and “Vitek - L compact 30 “. The studies were carried out using culture media, discs with antibacterial drugs from HIVEDIA (India) and test systems from BioMerieux (France). Statistical processing of the results was carried out using the Statistica 6.0 software package. In patients with PPI of knee, treatment was carried out in the following ways: surgical debridement with preservation of the endoprosthesis (EP), removal of the EP and placement of a cement spacer, removal of the EP, and arthrodesis of the knee joint. In patients with PPI after total hip arthroplasty, surgical debridement with preservation of the

EP and drainage of the focus of infection or resection arthroplasty with removal of the components of the EP and debridement of the focus of infection were used.

## Results

Surgical debridement of the site of infection is fundamental in the treatment of PPI. Surgical treatment was performed in 23 (63.9%) of 36 patients with PPI after total hip arthroplasty and in 36 (73.5%) of 49 patients with PPI after total knee arthroplasty. Thus, 59 out of 85 patients with PPI were operated on, which amounted to 69.4%. In patients with PPI after total hip arthroplasty, surgical debridement with preservation of the EP and drainage of the focus of infection was performed in 17 (73.9%) cases, and resection arthroplasty with removal of the components of the EP and debridement of the focus of infection in 6 (26.1%) cases. In patients with infection in the area

of the knee EP, surgical debridement was performed in 25 (69.4%), and resection arthroplasty with the removal of all components of the EP and with the placement of an articulating spacer - in 4 (11.1%). Compression arthrodesis of the knee joint with the wire-rod apparatus of external fixation "Medbiotech" (Republic of Belarus) was performed in 7 (19.5%) patients. To fix the limb, the wire-rod apparatus was applied in two planes - frontal and sagittal, connecting the apparatus bars to each other with additional bars. Analysis of the results of bacteriological studies of PPI showed that out of 36 (42.4%) crops after total hip arthroplasty, the growth of microflora was noted in 13 (56.5%) cases and out of 49 (57.6%) crops for PPI after total knee arthroplasty - in 10 (43.5%) studies. The study of the species structure of the isolated microorganisms showed that the leading positions in the spectrum of pathogens of PPI are occupied by gram-positive bacteria and the main role belongs to staphylococci (Table 1).

**Table 1** The quantitative composition of the causative agents of PPI in total arthroplasty of the knee and hip joints

Surgery	Total knee arthroplasty	Total hip arthroplasty	Total
<b>Causative agent</b>			
<i>Staphylococcus aureus</i>	4	7	11
<i>Acinetobacter baumannii</i>	2	3	5
<i>Klebsiella pneumonia ssp pneumonia</i>	2	1	3
<i>Pseudomonas aeruginosa</i>	2	2	4
Total	10	13	23

After total hip arthroplasty in patients with PPI, *Staphylococcus aureus* isolates were determined in 7 out of 13 studies, which accounted for 53.8%, and after total knee arthroplasty - in 4 out of 10 studies, which accounted for 40%. Among all pathogens of PPI, *Staphylococcus aureus* was isolated in 11 out of 23 crops (47.8%). Gram-negative microflora is represented by isolates (*Acinetobacter baumannii*, *Klebsiella pneumonia*, *Pseudomonas aeruginosa*) determined in 12 out of 23 studies, which is 52.2%. The sensitivity of the isolated microflora was determined to 40 antibacterial drugs (Table 2). Analysis of the data obtained showed that in the structure of pathogenic microorganisms that cause infectious complications both after total hip arthroplasty and after total knee arthroplasty, gram-positive cocci (*Staphylococcus aureus*), which are sensitive to most antibacterial drugs, prevail. With PPI of the hip joint, sensitivity to gentamicin, erythromycin, clindamycin was noted in 100% of cases; in 83% of cases - to oxacillin, linezolid, vancomycin; in 67% of cases - to tigecycline, nitrofurantoin, rifampicin; in 50% of cases - to moxifloxacin, quinupristin, trimenoprim; in 33% of cases - to cyloxacin, levofloxacin, tetracycline, teicoplanin, cefoxitin; in 16% of cases - to amikacin, ofloxacin, tobramycin. However, at the same time, resistance to chloramphenicol and doxycycline was

detected in 16% of cases. With PPI of the knee joint, sensitivity in 100% of cases was noted to linezolid, tigecycline; in 66% of cases - to moxifloxacin, quinupristin, vancomycin; in 33% of cases - to trimenoprim, tetracycline, clindamycin, levofloxacin, gentamicin. Resistance to amikacin was recorded in 66% of cases, while in 33% of cases, resistance to doxycycline, cefoxitin, tobramycin, teicoplanin, cyfloxacin was noted. Representatives of gram-negative microflora were found to be multi-resistant to most antibiotics. Thus, with PPI of the hip joint caused by *Pseudomonas aeruginosa*, sensitivity was noted only to amikacin, cefoperazone, meropenem, and resistance to chloramphenicol, rifampicin, nitrofurantoin, quinupristin, moxifloxacin, oxacillin. In PPI of knee, sensitivity was noted only to amikacin, imipinem, levofloxacin, and resistance to oxacillin, erythromycin, rifampicin, tobramycin, amoxiclav, chloramphenicol. Thus, in the structure of pathogens that cause infectious complications after prosthetics, gram-positive cocci (*Staphylococcus aureus*), which are sensitive to most antibacterial drugs, predominate, which most likely indicates their out-of-hospital origin, and antibiotic resistance of *Pseudomonas aeruginosa* is becoming an increasingly serious problem treating patients.

**Table 2** Sensitivity of microorganisms to tested chemotherapy drugs

Causative agent	Total hip arthroplasty				Total knee arthroplasty			
	<i>Staphylococcus aureus</i>	<i>Acinetobacter baumannii</i>	<i>Klebsiella pneumonia ssp pneumonia</i>	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>	<i>Acinetobacter baumannii complex</i>	<i>Klebsiella pneumonia ssp pneumonia</i>	<i>Pseudomonas aeruginosa</i>
<b>Antibiotic</b>								
Oxacillin	83%	-	-	-	-	-	-	-
Gentamicin	100%	-	-	-	33%	-	-	-
Ciprofloxacin	33%	-	-	-	-	-	-	-
Levofloxacin	33%	-	-	-	33%	-	50%	100%

Table Continued...

Causative agent	Total hip arthroplasty				Total knee arthroplasty			
	<i>Staphylococcus aureus</i>	<i>Acinetobacter baumannii</i>	<i>Klebsiella pneumoniae</i> ssp <i>pneumoniae</i>	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>	<i>Acinetobacter baumannii</i> complex	<i>Klebsiella pneumoniae</i> ssp <i>pneumoniae</i>	<i>Pseudomonas aeruginosa</i>
Moxifloxacin	50%	-	-	-	66%	-	-	-
Erythromycin	100%	-	-	-	-	-	-	-
Clindamycin	100%	-	-	-	33%	-	50%	-
Quinupristine dalfopristin	50%	-	-	-	66%	-	-	-
Linezolid	83%	-	-	-	100%	-	-	-
Vancomycin	83%	-	-	-	66%	-	-	-
Tetracycline	33%	-	-	-	33%	-	-	-
Tigecycline	67%	50%	-	-	100%	-	-	-
Nitrofurantoin	67%	50%	100%	-	-	-	-	-
Rifampicin	67%	-	-	-	-	-	-	-
Trimethoprim sulfamethoxazole	50%	-	-	-	33%	-	-	-
Teicoplanin	33%	-	-	-	-	-	-	-
Imipinem	-	-	-	-	-	-	-	100%
Meropenem	-	-	-	100%	-	-	-	-
Tobramycin	16%	-	-	-	-	-	-	-
Ofloxacin	16%	-	-	-	-	-	-	-
Amikacin	16%	50%	-	100%	-	-	-	100%
Cefoxitin	33%	-	-	-	-	-	-	-
Amoxiclav	-	-	-	-	-	50%	-	-
Cefoperazone	-	-	-	100%	-	50%	-	-
Chloramphenicol	-	-	100%	-	-	-	-	-
Doxycycline	-	-	-	-	-	-	50%	-

## Conclusions

- The main causative agents of PPI of the hip and knee joints, according to our study, are *S. aureus* (47.8%) and gram-negative microflora (*A. baumannii*, *K. pneumoniae*, *P. aeruginosa*) (52.2%). With PPI of the hip joint, *S. aureus* was isolated in 53.8% of cases, and with PPI of the knee joint in 40% of cases.
- When treating patients with PPI, the surgical method is preferred, which was used in 69.4% of cases.
- Staphylococcus aureus* is most sensitive to clindamycin, linezolid and vancomycin in cases of prosthetic hip and knee infections.
- In case of PPI of the hip and knee joint caused by *Pseudomonas aeruginosa* it is advisable to use amikacin.
- Levofloxacin and amikacin are effective for *staphylococcal* and *Pseudomonas aeruginosa* infections in prosthetic hip and knee joints.
- Resistance in PPI of the hip joint caused by gram-positive microorganisms is noted to chloramphenicol, doxycycline;

in PPI of the knee joint, resistance was recorded to amikacin, doxycycline, cefoxitin, tobramycin, teicoplanin, cyfloxacin.

- Resistance in PPI of the hip joint caused by *Pseudomonas aeruginosa* is noted to chloramphenicol, rifampicin, nitrofurantoin, quinupristin, moxifloxacin, oxacillin; with PPI of the knee joint, resistance was recorded to oxacillin, erythromycin, rifampicin, tobramycin, amoxiclav, chloramphenicol.

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## Conflicts of interest

The authors declare that there is no conflict of interest.

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