Contents lists available at ScienceDirect

CMI Communications

journal homepage: https://www.sciencedirect.com/journal/cmi-communications

Original article

Postoperative hip arthroplasty infections: A monocentric retrospective study in Liège University Hospital, Belgium, 2015-2023

Mathieu Bours [1], Arian Miandarbandi [1], Marie Ernst [2], Marie Thys [3], Majdouline El Moussaoui [4], Gilles Darcis [4,*]

[1] *University of Liège, Liège, Belgium*
[2] *Biostatistics and Research Method Center, University Hospital of Liège, Liège, Belgium*
[3] *Department of Medico-Economic Information, University Hospital of Liège, Liège, Belgium*
[4] *Infectious Diseases Department, University Hospital of Liège, Liège, Belgium*

ARTICLE INFO

Handling Editor: Dr. Marc Bonten

Keywords:
Hip arthroplasty
Prevention
Prosthetic joint infection
Risk factors

ABSTRACT

Objectives: Despite significant progress in prevention, periprosthetic joint infection (PJI) remains a major complication following hip arthroplasty. Our aim was to identify risk factors for hip PJI in order to inform and improve preoperative measures and postoperative monitoring.
Methods: We conducted a retrospective, single-centre study involving all adult patients (aged ≥18 years) who underwent hip arthroplasty at the University Hospital of Liège, Belgium, between 2015 and 2023.
Results: A total of 2852 patients undergoing hip replacement surgery were included with a median follow-up period of 34.8 months (interquartile range, 13.8–59.9 months). The incidence rate of subsequent PJI was 1.2% (34/2852). Most PJIs (25/34, 73.5%) occurred in the early phase, within 3 months of surgery. The most commonly isolated bacteria were *Staphylococcus* spp., including methicillin-resistant *Staphylococcus aureus*. Risk factors for hip PJI include a history of autoimmune inflammatory arthritis, preoperative anaemia and diabetes mellitus.
Conclusions: The incidence rate of PJI following hip replacement surgery is low. PJIs mostly occur within the first 3 months after surgery. We identified several factors associated with PJIs that could be targeted to reduce their incidence and inform the development of individualized patient follow-up strategies.

Introduction

Total hip arthroplasty (THA) or hemi-hip arthroplasty (HHA) has been the most common surgical procedure performed worldwide for the past 10 years to treat joint osteoarthritis, rheumatological diseases and certain types of fractures caused by osteoporosis [1]. Hip replacement surgery is becoming more common for various reasons, including an ageing population and increased rates of obesity. It can reduce pain, improve mobility and enhance quality of life. It is considered safe and effective. However, it is essential to be aware of the potential complications associated with this surgery. These can be general or specific to the procedure and may occur during the surgery, immediately afterwards, or weeks, months, or even years later. Among the postoperative complications, prosthetic joint infection (PJI) prosthetic joint infection is one of the worst.

There is considerable variability in the literature, but the risk of PJI is generally considered to be approximately 0.3% to 2% [2]. Although the probability of infection is relatively low, the consequences and long-term implications should not be underestimated. These infections around periprosthetic material are related to significant morbidity and mortality and account for a substantial proportion of healthcare expenditure [3]. PJIs often require the removal of the prosthesis, an extended course of treatment with antimicrobial agents and one- or two-stage reimplantation of the prosthesis. This may result in lasting or even permanent disability [4]. Furthermore, several studies have demonstrated that the management of PJI is costly and imposes a significant economic burden on the healthcare system [5].

Despite the dramatic clinical consequences of PJIs, there are major knowledge gaps concerning the epidemiology, risk factors and microbiology of these infections. Identifying potential risk factors is important and could help prevent such infections. A study conducted in England by Ridgeway and colleagues [6] demonstrated that a greater risk of PJI in patients undergoing arthroplasty is associated with three major factors, including advanced age, the presence of underlying illnesses (as reflected by an increased American Society of Anaesthesiologists [ASA] score) and an aetiology related to traumatic injury, rather than being related to the type of procedure. Other studies have shown that male sex, obesity, alcohol abuse, surgery time, rheumatoid arthritis, coronary

* Corresponding author: Gilles Darcis, Infectious Diseases Department, University Hospital of Liège, Avenue de l'Hôpital 1, 4000 Liège, Belgium.
E-mail address: gdarcis@chuliege.be (G. Darcis).

https://doi.org/10.1016/j.cmicom.2025.105133
Received 21 January 2025; Received in revised form 5 August 2025; Accepted 14 August 2025
Available online 18 August 2025
2950-5909/© 2025 The Authors. Published by Elsevier Ltd on behalf of European Society of Clinical Microbiology and Infectious Diseases. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/)

artery disease, pulmonary hypertension and diabetes mellitus are independent risk factors for PJI after primary THA [7,8]. In contrast, drain usage has been described as a protective factor [7].

THA has evolved over time due to the development of new technologies, implant design improvements and surgical techniques (e.g. implant material, fixation, bearing surfaces, size, minimally invasive tissue-sparing approaches or pain management protocols). Complications such as infections and associated factors will likely also change over time. Our study aimed to identify the incidence rates of patient and surgical factors associated with PJI and to determine the microbiology of PJI in recent years.

Methods

Design and participants

This single-centre monocentric retrospective study was conducted at the University Hospital of Liège, Belgium, which is a tertiary referral centre for joint arthroplasty with several surgeons specializing in these operations. Adult patients (≥18 years) undergoing total or HHA between November 2015 and May 2023 were included. Follow-up was censored at the time of patient death or on 1 July 2023. Data were collected from electronic health records at the time of the surgery. Individuals who underwent two surgeries were considered only once at the time of the first surgery, to avoid clustering. The dataset included demographic characteristics, surgical procedures, laboratory results and microbiological culture results. These included age, body mass index, sex, smoking status (active or former smoker), ASA score, preoperative anaemia, presence of pre-existing autoimmune joint disease and diabetes. Immunosuppression (defined as receiving immunosuppressive therapy or chemotherapy for active cancer or being infected with HIV) was also included as a baseline characteristic. Data regarding the procedure were also collected, including the type of surgery (elective vs. emergency) and operating time. Identifying patients with infections followed a stepwise process. First, patients were flagged for individual review if they had received advice from an infectious disease specialist (notified in the electronic health records), had positive microbiological cultures for prosthetic infection or had an (ICD) International Classification of Diseases code indicating prosthetic infection or had undergone prosthetic revision (codes T84.51 and T84.52 and codes starting with 0SPB0 or 0SP90). The patients' files were then opened and reviewed (a step performed by M.B. and G.D.) to confirm the infection diagnosis.

The time to infection is defined as the period between the day of HHA/THA and the day on which the infection was diagnosed. PJI was then classified as early (fewer than 3 months after surgery), delayed (between 3 and 12 months) or late (more than 12 months) depending on the interval.

In cases of infection, we identified the causative microorganisms. The results were classified as follows: culture-negative, defined as no growth of organisms; culture-positive, defined as the growth of one or more bacteria (simple vs. polymicrobial growth) and fungal species isolated from the culture.

Approval for the study protocol was obtained from the local ethics review committee (Comité d'Ethique Hospitalo-Facultaire Universitaire de Liège, reference number 2023-159). Individual consent was waived due to the retrospective nature of the study and the coding of the data. This study followed the Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting.

Statistical methods

Categorical variables are expressed as numbers and percentages (%). Quantitative variables are reported as means and standard deviations, along with extreme values. The time between surgery and infection was depicted via Kaplan–Meier curves. The impact of potential risk factors on the probability of an infection was modelled via a univariate Cox regression model (if required, with a Firth correction). Each model is summarized by the hazard ratio (HR), 95% CI and p-value. Missing values were not imputed, except for smoking, where a nonreported value was associated with nonsmoker. A value of $p < 0.05$ was considered significant. Computations were performed via SAS version 9.4, and graphics were generated via R software (version 4.3.1).

Results

Patient characteristics

The cohort consists of 2852 primary prosthetic hip surgeries. Eleven surgeons performed hip arthroplasty during the study period. The median follow-up time was 34.8 months (interquartile range, 13.8–59.9 months). The patients' characteristics are described in Table 1. The mean age was 71.4 years (range, 16–102 years). Most participants were female (61.3%; 1851/2852). The mean body mass index was 26.0 kg/m^2. Of the participants, 16.2% (466/2852) had diabetes, and 20.5% (481/2376) had preoperative anaemia at the time of surgery. Sixty-five participants (2.3%, 65/2852) were classified as immunosuppressed, primarily due to receiving immunosuppressive therapy (Table 1).

Incidence and risk factors for PJIs

We documented 34 cases of PJI (Table 1), accounting for 1.2% (34/2852) of all postsurgery PJIs during the three phases. Most PJIs occurred in the early phase (25/34, 73.5%). Two of them (2/34, 5.9%) were classified as delayed and seven (7/34 [20.6%]) as late (Table 1).

We performed a survival analysis to determine the probability of infection according to the time since surgery (Fig. 1). Our findings indicate that, considering censored data, the probability of infection within 3 months is estimated at 0.90%, and this figure barely increases at 1 year (Fig. 1).

The characteristics of patients with and without infections are described in Table 1. We identified several risk factors associated with postoperative infection. Preoperative anaemia was associated with a greater risk of PJI (HR = 3.46; p 0.0003) (Table 1). Diabetes mellitus (HR = 2.45; p 0.015) and pre-existing autoimmune joint disease (HR = 22.3; $p < 0.0001$) were other parameters associated with a greater risk of PJI. In contrast, age, sex, body mass index and immunosuppression were not identified as risk factors for infection in our analysis. A greater proportion of postoperative infections were observed in the nonelective intervention group (emergency surgery), the group with an ASA score higher than 2 and the group with a longer surgical time. However, this did not reach statistical significance (Table 1).

We also examined the risk factors for early infection, which we defined as infection within 3 months after surgery ($N = 25$) (Table 2). The risk of early infection was found to be higher in patients with pre-existing autoimmune joint disease (HR = 25.8; $p < 0.0001$), preoperative anaemia (HR = 2.74; p 0.014) and diabetes mellitus (HR = 2.41; p 0.041). We also observed a higher proportion of postoperative infections in patients who underwent emergency surgery and experienced prolonged surgical times. However, these differences did not reach statistical significance (Table 2).

Microbiological studies of early, delayed and late PJIs

Of the 34 patients with incident PJIs, none had a missing microbiological culture specimen or result. Additionally, none of the patients had a culture-negative result (Table 3). Four PJIs (11.8%) were polymicrobial. All of these occurred in the early postoperative period. Gram-positive infections were the most common across

Table 1
Comparison of characteristics for patients without or with infection.

Variable	Categories	*N*	Noninfected (N = 2818) Mean ± SD *n* (%)	*N*	Infected (N = 34) Mean ± SD *n* (%)	HR	95% CI	p
Age (y)		2818	71.4 ± 13.3	34	69.7 ± 16.6	0.99	0.97, 1.02	0.64
BMI (kg/m^2)		2622	26.0 ± 5.2	34	26.1 ± 6.7	0.99	0.94, 1.07	0.95
Obesity (BMI ≥ 30)	Yes vs. no	2622	535 (20.4)	34	8 (23.5)	1.16	0.52, 2.56	0.72
Obesity type II (BMI ≥ 35)	Yes vs. no	2622	130 (5.0)	34	1 (2.9)	0.56	0.08, 4.06	0.56
Obesity type III (BMI ≥ 40)	Yes vs. no	2622	31 (1.2)	34	1 (2.9)	2.49	0.34, 18.2	0.37
Sex	M vs. F	2818	1083 (38.4)	34	18 (52.9)	1.78	0.91, 3.49	0.094
Smoking	Yes vs. no/NA	2818	808 (28.7)	34	12 (35.3)	1.33	0.66, 2.70	0.42
ASA score		2515		32				0.86
	I		210 (8.3)		2 (6.3)	1.00		
	II		1833 (72.9)		24 (75.0)	1.46	0.34, 6.17	
	III–IV–V		472 (18.8)		6 (18.8)	1.56	0.31, 7.74	
Preoperative anaemia	Yes vs. no	2342	466 (19.9)	34	15 (44.1)	3.46	1.75, 6.81	**0.0003**
Preoperative diabetes	Yes vs. no	2818	455 (16.1)	34	11 (32.4)	2.45	1.19, 5.03	**0.015**
Elective surgery	Yes vs. no	2818	1777 (63.1)	34	20 (58.8)	0.74	0.37, 1.47	0.39
Long operation (>115 min)	Yes vs. no	1407	472 (33.5)	18	9 (50.0)	1.74	0.69, 4.40	0.24
Pre-existing joint disease	Yes vs. no	2818	87 (3.1)	34	15 (44.1)	22.3	11.3, 43.9	**<0.0001**
Immunosuppression	Yes vs. no	2818	64 (2.3)	34	1 (2.9)	1.36	0.19, 9.95	0.76
Infection (N = 34)								
Timing of infection								
		Early (<3 mo)			25 (73.5)			
		Delayed (3–12 mo)			2 (5.9)			
		Late (>1 y)			7 (20.6)			

Bold values correspond to p<0.05.
ASA, American Society of Anaesthesiologists; BMI, body mass index; HR, hazard ratio; SD, standard deviation; M: Male ; F: Female; NA: Not available.

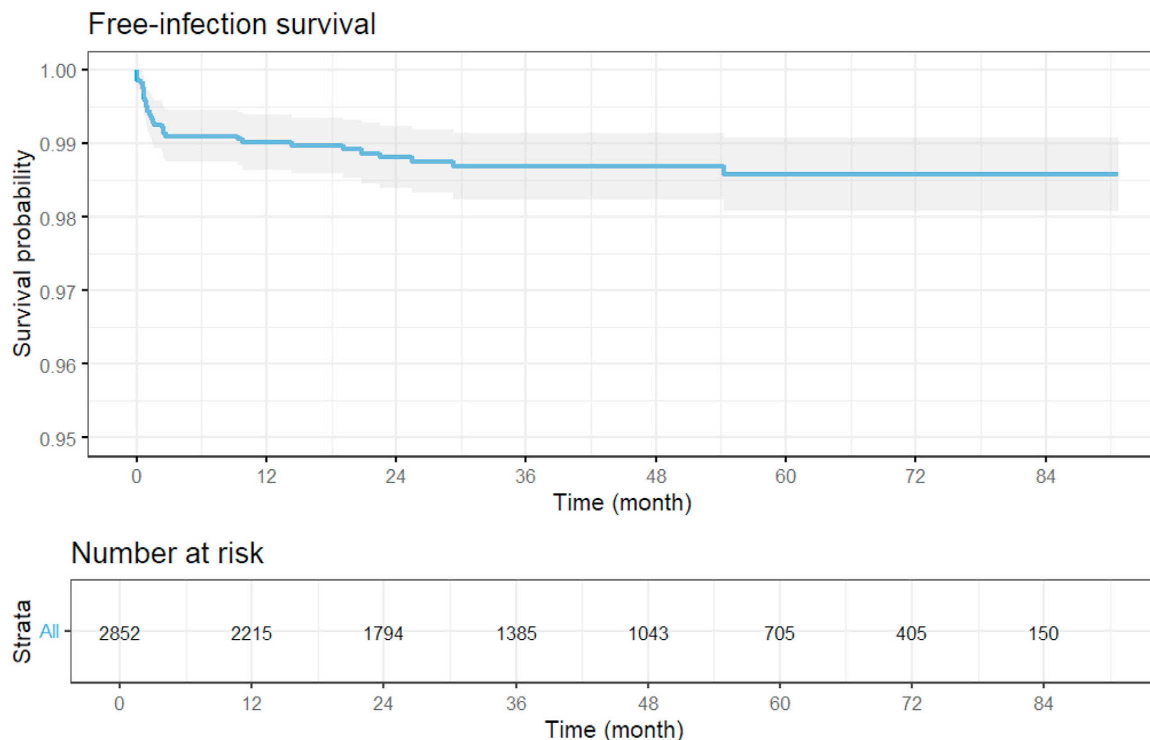

Fig. 1. Kaplan–Meier curve for infection-free survival. Line: probability of survival without infection. Grey shading: CI.

Table 2
Comparison of characteristics for patients without or with early infection.

Variable	Categories	*N*	No early infection (*N* = 2827) Mean ± SD *n* (%)	*N*	Early infection (*N* = 25) Mean ± SD *n* (%)	HR	95% CI	p
Age (y)		2827	71.4 ± 13.4	25	73.6 ± 14.6	1.02	0.98, 1.05	0.36
BMI (kg/m^2)		2631	26.0 ± 5.2	25	26.2 ± 7.4	1.01	0.93, 1.08	0.87
Obesity (BMI ≥ 30)	Yes vs. no	2631	537 (20.4)	25	6 (24.0)	1.21	0.48, 3.02	0.69
Obesity type II (BMI ≥ 35)	Yes vs. no	2631	130 (4.9)	25	1 (4.0)	0.79	0.11, 5.87	0.82
Obesity type III (BMI ≥ 40)	Yes vs. no	2631	31 (1.2)	25	1 (4.0)	3.45	0.47, 25.5	0.23
Sex	M vs. F	2827	1088 (38.5)	25	13 (52.0)	1.72	0.78, 3.76	0.18
Smoking	Yes vs. no/NA	2827	811 (28.7)	25	9 (36.0)	1.39	0.61, 3.14	0.43
ASA score		2524		23				0.60
	I		211 (8.4)		1 (4.3)	1.00		
	II		1838 (72.8)		19 (82.6)	2.20	0.30, 16.4	
	III–IV–V		475 (18.8)		3 (13.0)	1.40	0.15, 13.5	
Preoperative anaemia	Yes vs. no	2351	471 (20.0)	25	10 (40.0)	2.74	1.23, 6.09	**0.014**
Preoperative diabetes	Yes vs. no	2827	458 (16.2)	25	8 (32.0)	2.41	1.04, 5.78	**0.041**
Elective surgery	Yes vs. no	2827	1783 (63.1)	25	14 (56.0)	0.71	0.32, 1.56	0.39
Long operation (>115 min)	Yes vs. no	1415	476 (33.6)	10	5 (50.0)	1.94	0.56, 6.70	0.29
Pre-existing joint disease	Yes vs. no	2827	90 (3.2)	25	12 (48.0)	25.8	11.8, 56.6	**<0.0001**
Immunosuppression	Yes vs. no	2827	64 (2.3)	25	1 (4.0)	1.85	0.25, 13.4	0.56

Bold values correspond to p<0.05.
ASA, American Society of Anaesthesiologists; BMI, body mass index; HR, hazard ratio; SD, standard deviation; M: Male ; F: Female; NA: Not available.

Table 3
Microbiological studies.

Microbiology	Species	All infections (*N* = 34) *n* (%)	Early infections (*N* = 25) *n* (%)	Delayed and late infections (*N* = 9) *n* (%)
Polymicrobial infections		**4 (11.8)**	**4 (16)**	**0 (0)**
Organism	Fungal infection	0 (0.0)	0 (0.0)	0 (0.0)
Gram-positive		**29 (85.3)**	**20 (80.0)**	**9 (100.0)**
	Staphylococcus	24 (70.6)	18 (72.0)	6 (66.7)
	Coagulase negative	10 (29.4)	6 (24.0)	4 (44.4)
	Epidermidis	*9 (26.5)*	*5 (20.0)*	*4 (44.4)*
	Other	*1 (2.9)*	*1 (4.0)*	*0 (0.0)*
	Staphylococcus aureus	15 (44.1)	13 (52.0)	2 (22.2)
	MSSA	*10 (29.4)*	*9 (36.0)*	*1 (11.1)*
	MRSA	*5 (14.7)*	*4 (16.0)*	*1 (11.1)*
	Cutibacterium acnes	2 (5.9)	1 (4.0)	1 (11.1)
	Cutibacterium avidum	1 (2.9)	0 (0.0)	1 (11.1)
	Enterococcus faecalis	2 (5.9)	2 (8.0)	0 (0.0)
	Streptococcus oralis	1 (2.9)	0 (0.0)	1 (11.1)
Gram-negative		**6 (17.6)**	**6 (24.0)**	**0 (0.0)**
	Enterobacter aerogenes	1 (2.9)	1 (4.0)	0 (0.0)
	Escherichia coli	1 (2.9)	1 (4.0)	0 (0.0)
	Pseudomonas aeruginosa	2 (5.9)	2 (8.0)	0 (0.0)
	Klebsiella pneumoniae	3 (8.8)	3 (12.0)	0 (0.0)
No germ found		0 (0.0)	0 (0.0)	0 (0.0)

Bold values correspond to p<0.05.
Patients with polymicrobial infections are counted several times in the detailed microbiological study. Therefore, the total sum exceeds 100%. MRSA, methicillin-resistant *S. aureus*; MSSA, methicillin-sensitive *S. aureus*.

all postoperative periods, with coagulase-negative staphylococci and methicillin-sensitive *Staphylococcus aureus* being frequently identified (10/34 [29.4%]). *Staphylococcus epidermidis* (4/9 [44.4%]) and *S. aureus* (either methicillin-sensitive or -resistant) (2/9 [22.2%]) were more prevalent in delayed and late PJIs (Table 3). Gram-negative organisms were observed in six of 34 infections (17.6%), occurring in early PJIs. *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* were the most common Gram-negative organisms.

Discussion

PJI is arguably the most significant complication following hip arthroplasty. Over the past few years, the number of hip arthroplasties has increased significantly, primarily due to the improvement in quality of life it provides. We found that PJI is relatively rare after THA/HHA with an incidence of 1.2%. The majority of microorganisms isolated from PJIs were *S. aureus* and coagulase-negative staphylococci.

Our study also demonstrated that pre-existing autoimmune inflammatory arthritis, preoperative anaemia and diabetes are risk factors for PJI.

The incidence of PJI in our study was low, which is consistent with previous studies reporting similar rates [6,9,10]. Most infections occurred within the first 3 months after surgery, as observed by other groups studying hip or knee arthroplasties [11,12]. Our results emphasize the importance of developing and testing interventions to mitigate the risk of early PJI [11].

It is crucial to identify the factors that contribute to the risk of PJI in order to develop strategies to reduce this complication. It would also help to categorize patients according to their risk level, which could inform postoperative monitoring. Our research identified pre-existing autoimmune joint disease, preoperative anaemia and diabetes as significant risk factors for PJI. These factors are interconnected through various pathophysiological mechanisms such as wound ischaemia, perivascular disease and chronic inflammation, which can lead to impaired wound healing and wound dehiscence [13,14]. Patients with diabetes are also particularly susceptible to infection due to weakened immune defences and reduced tissue concentrations of antibiotics caused by macroangiopathic and microangiopathic alterations. These results are consistent with those of other reports and meta-analyses, which also revealed the detrimental effects of additional parameters, including steroid use, male sex, obesity, alcohol abuse and an ASA scale higher than 2 [9,15,16]. Identifying patients with diabetes or hyperglycaemia and implementing strict perioperative glycaemic control will minimize the risk of infection following various surgical procedures.

Microbiological studies are necessary to inform clinicians about the use of antibiotic prophylaxis and antibiotics after surgery. For patients undergoing total hip surgery, the recommended regimen is a first-generation cephalosporins (cefazolin) [4]. In institutions with a high prevalence of methicillin-resistant *S. aureus* (MRSA) surgical site infections, or for patients known to be colonized with MRSA, vancomycin should be added to, or used instead of, cefazolin for routine antimicrobial prophylaxis. It should be noted that the observation that *S. aureus* colonisation increases the risk of PJI often resulted in the implementation of preoperative screening and decolonization protocols for *S. aureus*. Universal screening is still a subject of much debate and has not been implemented in our centre, primarily due to logistical issues surrounding screening and decolonization. The advantage of a screen-and-treat strategy is that results from MRSA screening can inform antibiotic prophylaxis. However, universal decolonization prior to targeted procedures is a more cost-effective strategy. Universal decolonization may also be easier to implement.

Our microbiology results are consistent with those reports from other European countries, the USA and the UK [6,17–19], showing that the most common causative agents of PJI are *S. aureus* and coagulase-negative staphylococci. Most *S. aureus* strains were methicillin-sensitive *S. aureus*, particularly in the early infection group. Gram-negative organisms, which are typically resistant to first-generation cephalosporins, were rarely isolated in our study and were only found in the group with early infections. *Enterococcus*, which is naturally resistant to cephalosporins, was still isolated from 4.2% of PJIs. Future studies with a larger sample size should aim to determine the profiles and antimicrobial susceptibility of isolated microbial agents in order to assess the need for other antibiotic prophylaxis. Such studies would help to clarify the role of vancomycin and teicoplanin as prophylactic antibiotics in hip surgery. In addition to the choice of antibiotic, the ideal time at which to administer antibiotics remains controversial. Most agree that prophylaxis should end within an hour of surgery starting, meaning that some agents, such as vancomycin with its longer infusion time, need to be started a few hours earlier.

This study has some limitations. Firstly, it cannot be ruled out that patients with PJIs may have required follow-up at another centre, which could result in an underestimation of the prevalence of PJIs in our study. Secondly, revisions attributed to aseptic loosening may ultimately be driven by low-grade infection. This could explain the absence of culture-negative PJIs in our study, although another possible cause is the reluctance of infectious diseases specialists to treat PJIs at our centre without a positive culture. They prefer to take new microbiological samples after longer antibiotic window. Third, single-centre studies, while potentially having some advantages in terms of control, face significant limitations regarding generalizability.

In conclusion, the incidence rate of PJI following THA/HHA in our cohort is low. PJIs mostly occur in the first 3 months after surgery. The isolated bacteria are mostly *Staphylococcus* spp., including MRSA, but the contribution of Gram-negative bacteria and *Enterococcus* spp. should not be neglected. We have identified factors associated with PJIs that could be used to individualize patient follow-up strategies and that could be targeted to reduce the rate of this devastating postoperative complication.

Declaration of competing interest

The authors declare that they have no conflicts of interest.

CRediT authorship contribution statement

Mathieu Bours: Writing – original draft, Investigation, Formal analysis, Conceptualization. **Arian Miandarbandi:** Writing – review & editing. **Marie Ernst:** Writing – review & editing, Validation, Methodology, Investigation, Formal analysis. **Marie Thys:** Methodology, Investigation, Data curation, Conceptualization. **Majdouline El Moussaoui:** Writing – review & editing. **Gilles Darcis:** Writing – original draft, Validation, Supervision, Investigation, Funding acquisition, Formal analysis, Conceptualization.

Financial report

G.D. is an FNRS clinical researcher. M.B. received support from the University of Liège for performing research analysis.

Data availability

The data presented in this study are available upon request from the corresponding authors.

Acknowledgements

We thank Laurence Seidel and Jean-Baptiste Giot for their precious advice during the revision of the manuscript.

References

[1] Reginster JY, Gillet P, Gosset C. Secular increase in the incidence of hip fractures in Belgium between 1984 and 1996: Need for a concerted public health strategy. Bull World Health Organ 2001;79:942–6.

[2] Nelson SB, Pinkney JA, Chen AF, Tande AJ. Executive summary: Periprosthetic joint infection—Current clinical challenges. Clin Infect Dis 2023;77:939–40. doi:10.1093/cid/ciad457.

[3] Beam E, Osmon D. Prosthetic joint infection update. Infect Dis Clin North Am 2018;32:843–59. doi:10.1016/j.idc.2018.06.005.

[4] Bratzler DW, Dellinger EP, Olsen KM, Perl TM, Auwaerter PG, Bolon MK, et al. Clinical practice guidelines for antimicrobial prophylaxis in surgery. Am J Health Syst Pharm 2013;70:195–283. doi:10.2146/ajhp120568.

[5] Tsaras G, Osmon DR, Mabry T, Lahr B, St Sauveur J, Yawn B, et al. Incidence, secular trends, and outcomes of prosthetic joint infection: A population-based study, Olmsted county, Minnesota, 1969-2007. Infect Control Hosp Epidemiol 2012;33:1207–12. doi:10.1086/668421.

[6] Ridgeway S, Wilson J, Charlet A, Kafatos G, Pearson A, Coello R. Infection of the surgical site after arthroplasty of the hip. J Bone Joint Surg Br 2005;87:844–50. doi:10.1302/0301-620X.87B6.15121.

[7] Kong L, Cao J, Zhang Y, Ding W, Shen Y. Risk factors for periprosthetic joint infection following primary total hip or knee arthroplasty: A meta-analysis. Int Wound J 2017;14:529–36. doi:10.1111/iwj.12640.

[8] Triantafyllopoulos GK, Soranoglou VG, Memtsoudis SG, Sculco TP, Poultsides LA. Rate and risk factors for periprosthetic joint infection among 36,494 primary total hip arthroplasties. J Arthroplasty 2018;33:1166–70. doi:10.1016/j.arth.2017.11.040.

[9] Kunutsor SK, Whitehouse MR, Blom AW, Beswick AD, Team INFORM. Patient-related risk factors for periprosthetic joint infection after total joint arthroplasty: A systematic review and meta-analysis. PLoS One 2016;11:e0150866. doi:10.1371/journal.pone.0150866.

[10] Wolff DT, Shah NV, Eldib AM, Shah AT, Panchal AJ, Krasnyanskiy B, et al. Differences in infection rates by surgical approach in total hip arthroplasty and patient sex: A systematic review. Iowa Orthop J 2022;42:60–5.

[11] Weinstein EJ, Stephens-Shields AJ, Newcomb CW, Silibovsky R, Nelson CL, O'Donnell JA, et al. Incidence, microbiological studies, and factors associated with prosthetic joint infection after total knee arthroplasty. JAMA Netw Open 2023;6:e2340457. doi:10.1001/jamanetworkopen.2023.40457.

[12] Liukkonen RJ, Honkanen M, Reito AP, Skyttä ET, Karppelin M, Eskelinen AP. Trends in revision hip arthroplasty for prosthetic joint infection: A single-center study of 423 hips at a high-volume center between 2008 and 2021. J Arthroplasty 2023;38:1151–9. doi:10.1016/j.arth.2023.02.061.

[13] Fraval A, Hozack WJ. Managing the patient with peripheral vascular disease before total knee arthroplasty surgery. Orthop Clin North Am 2023;54:259–67. doi:10.1016/j.ocl.2023.02.011.

[14] Yeganeh MH, Kheir MM, Shahi A, Parvizi J. Rheumatoid arthritis, disease modifying agents, and periprosthetic joint infection: What does a joint surgeon need to know? J Arthroplasty 2018;33:1258–64. doi:10.1016/j.arth.2017.11.031.

[15] Tojo KJ, Ohtori A. Pharmacokinetic model of intravitreal drug injection. Math Biosci 1994;123:59–75. doi:10.1016/0025-5564(94)90018-3.

[16] Ritter C, Paddle B. Testosterone and hydrocortisone-stimulated responses of reduced pyridine nucleotide fluorescence in prostates cultured from castrate rats. Biochim Biophys Acta 1967;143:547–53. doi:10.1016/0005-2728(67)90059-x.

[17] Kapadia BH, Berg RA, Daley JA, Fritz J, Bhave A, Mont MA. Periprosthetic joint infection. Lancet 2016;387:386–94. doi:10.1016/S0140-6736(14)61798-0.

[18] Azarkane M, Boussakri H, Shimi M, Elibrahimi A, Elmrini A. Les complications tardives de prothèse totale de la hanche: À propos de 42 cas [Late complications of total hip prosthesis: Apropos of 42 cases]. Pan Afr Med J 2013;14:17. doi:10.11604/pamj.2013.14.17.2265.

[19] Ure KJ, Amstutz HC, Nasser S, Schmalzried TP. Direct-exchange arthroplasty for the treatment of infection after total hip replacement. An average ten-year follow-up. J Bone Joint Surg Am. 1998;80:961–8. doi:10.2106/00004623-199807000-00004.