In-hospital mortality of patients with periprosthetic joint infection

demographic, comorbidity, and complication profiles of 52,286 patients

From All hospitals across Germany

Correspondence should be sent to M. Rupp rupp.markus@ukr.de

Cite this article:
Bone Jt Open 2024;5(4):
367–373.

DOI: 10.1302/2633-1462.54.BJO-2023-0162.R1

J. Reinhard,[1,2] S. Lang,[2] N. Walter,[2] M. Schindler,[2] S. Bärtl,[2,3] D. Szymski,[2] V. Alt,[2] M. Rupp[2]

[1]Department of Orthopaedic Surgery, University Medical Center Regensburg, Regensburg, Germany
[2]Department of Trauma Surgery, University Medical Center Regensburg, Regensburg, Germany
[3]Center for Musculoskeletal Surgery, Charité – University Medicine Berlin, Berlin, Germany

Aims
Periprosthetic joint infection (PJI) demonstrates the most feared complication after total joint replacement (TJR). The current work analyzes the demographic, comorbidity, and complication profiles of all patients who had in-hospital treatment due to PJI. Furthermore, it aims to evaluate the in-hospital mortality of patients with PJI and analyze possible risk factors in terms of secondary diagnosis, diagnostic procedures, and complications.

Methods
In a retrospective, cross-sectional study design, we gathered all patients with PJI (International Classification of Diseases (ICD)-10 code: T84.5) and resulting in-hospital treatment in Germany between 1 January 2019 and 31 December 2022. Data were provided by the Institute for the Hospital Remuneration System in Germany. Demographic data, in-hospital deaths, need for intensive care therapy, secondary diagnosis, complications, and use of diagnostic instruments were assessed. Odds ratios (ORs) with 95% confidence intervals (CIs) for in-hospital mortality were calculated.

Results
A total of 52,286 patients were included, of whom 1,804 (3.5%) died. Hypertension, diabetes mellitus, and obesity, the most frequent comorbidities, were not associated with higher in-hospital mortality. Cardiac diseases as atrial fibrillation, cardiac pacemaker, or three-vessel coronary heart disease showed the highest risk for in-hospital mortality. Postoperative anaemia occurred in two-thirds of patients and showed an increased in-hospital mortality (OR 1.72; $p < 0.001$). Severe complications, such as organ failure, systemic inflammatory response syndrome (SIRS), or septic shock syndrome showed by far the highest association with in-hospital mortality (OR 39.20; 95% CI 33.07 to 46.46; $p < 0.001$).

Conclusion
These findings highlight the menace coming from PJI. It can culminate in multi-organ failure, SIRS, or septic shock syndrome, along with very high rates of in-hospital mortality, thereby highlighting the vulnerability of these patients. Particular attention should be paid to patients with cardiac comorbidities such as atrial fibrillation or three-vessel coronary heart disease. Risk factors should be optimized preoperatively, anticoagulant therapy stopped and restarted on time, and sufficient patient blood management should be emphasized.

Bone & Joint Open

Take home message

- This cross-sectional, epidemiological study revealed an in-hospital mortality of 3.5%.
- Periprosthetic joint infection (PJI) can result in multi-organ failure, systemic inflammatory response syndrome, or septic shock syndrome, going along with very high rates of in-hospital mortality.
- PJI should not be underestimated, and patients should liberally receive early intensive care therapy.
- Particular attention should be paid to patients with cardiac comorbidities, such as atrial fibrillation or three-vessel coronary heart disease.

Introduction

Periprosthetic joint infection (PJI) demonstrates the most feared complication after total joint replacement (TJR).[1,2] It may result in disability, higher rates of reinfection, and can result in disarticulation of the affected limb or even death.[3-5] In addition, a protracted therapy with long hospital stays demonstrates a huge economic burden for the healthcare system.[6,7] Premkumar et al[7] analyzed the costs caused by PJI of the knee and the hip in the USA, and predicted the costs for 2030 to be $1.85 billion. Over the last two decades, TJR has become one of the most frequent and most successful operations.[8] Because of an ageing population, in 2040 there is an estimated increment of procedures of 284% for total hip arthroplasty (THA) and 401% for total knee arthroplasty (TKA) in the USA.[9,10]

In Germany and most European countries, the expected increment is estimated to be less pronounced due to a decreasing population.[10] The growing number of TJRs will result in a constant increment of PJIs over the next years.[2,6] For primary TJR, an infection rate of 1.52% and an even higher rate after surgical revision is reported.[11] Many studies focus on possible risk factors that predispose to the development of a PJI.[1,6,12] Although PJI entails high rates of morbidity and mortality, only a few studies analyzed the impact of PJI on in-hospital mortality.[13-15] According to the recent literature, the overall mortality rate of patients suffering from PJI is 3.2 to 3.7 times higher than of those without joint infection.[3,16] A database search revealed a one-year mortality rate of 4.22% after PJI of the hip and a five-year mortality as high as 21%.[17] A recent study showed that patients with PJI have an even higher risk for in-hospital mortality than those having interventional coronary procedures, cholecystectomy, kidney transplant, or carotid surgery.[15] Therefore, the aim of the present study was to analyze demographic, comorbidity, and complication profiles of all patients who had in-hospital treatment due to PJI in Germany between 2019 and 2022. Furthermore, the study aimed to evaluate the in-hospital mortality of patients with PJI and potential risk factors in terms of secondary diagnosis, diagnostic procedures, and complications that lead to higher rates of mortality.

Methods

In a retrospective, cross-sectional study design, patients suffering from PJI (ICD-10 code T84.5),[18] and requiring in-hospital treatment in Germany between 1 January 2019 and 31 December 2022, were identified. Data were provided by the Institute for the Hospital Remuneration System (InEK; Germany). The InEK system was established during the COVID-19 pandemic to receive robust and detailed data about the workload in German hospitals. For this reason, it only enables data from 1 January 2019 onwards. Every hospital in Germany is forced to provide its data. The InEK imposes main diagnosis, secondary diagnosis of comorbidities, complications, and resulting procedures (all ICD-10 coded).[18] The correct coding of diagnosis can be assumed since diagnosis-related groups (DRGs) lump sum payment relies on it. Data were assessed with the InEK data browser, which was accessed on 5 April 2023.[19] All extracted data were anonymized. We gathered all patients suffering from PJI (ICD-10 code: T84.5) and assessed the total case numbers, demographic data (sex, age), number of in-hospital deaths, number of patients with a need for intensive care unit therapy, as well as secondary diagnosis, the use of diagnostic instruments, and complications. Moreover, the odds ratio (OR) and confidence interval (CI) for in-hospital mortality were calculated considering secondary diagnosis, diagnostic procedures, and complications as potential risk factors.

Due to the fact that only anonymized data from an administrative, central database were used, neither informed consent nor institutional review board (IRB) approval was needed.

Statistical analysis

Data are noted in absolute and relative frequencies. For comparison of categorical variables, we used chi-squared test. Statistical significance was considered $p \leq 0.05$. The OR and 95% CI for the in-hospital mortality were calculated. Statistical analysis was performed with SPSS (IBM, USA) and Excel 2019 (Microsoft, USA).

Results

We identified 52,286 patients who suffered from PJI (ICD-10 code: T84.5) and received in-hospital treatment between 1 January 2019 and 31 December 2022 in Germany. The majority of patients were aged above 60 years (44,757; 85.6%), and sex was almost equally distributed (25,937 males vs 26,349 females). Patients aged above 80 years showed a higher in-hospital mortality (OR 2.19; 95% CI 2.032.37, $p < 0.001$). The mean duration of hospitalization was 20.4 days (standard deviation (SD) 17.9). One-quarter of patients (13,177 (25.2%)) needed intensive care therapy. Those patients showed a significantly higher in-hospital mortality rate (OR 3.03; 95% CI 2.82 to 3.27; $p < 0.001$, chi-squared test). Out of 52,286 patients, 1,804 (3.5%) died (Table I).

Risk factors for in-hospital mortality in terms of secondary diagnosis

The most frequent secondary diagnosis was hypertension, which was observed in more than half of the population (27,378 patients). Overall, 9,739 patients (19%) took oral anticoagulation. In all, 8,829 patients (17%) suffered from diabetes mellitus. Chronic renal insufficiency (Kidney Disease: Improving Global Outcomes (KDIGO) severity score > level III)[20] was reported in 6,332 patients (12%). Paroxysmal atrial fibrillation was seen in 6,095 patients (12%), while permanent atrial fibrillation was detected in 2,756 patients 5% (2,756 patients); 4,395 patients (8%) had hyperuricemia. A cardiac pacemaker/defibrillator was

Table I. Demographic data of the 52,286 included patients with periprosthetic joint infection.

Variable	Absolute (relative) frequencies	OR (95% CI)	p-value*
Age, yrs, n (%)			
18 to 29	119 (0.2)	0.24 (0.03 to 1.7)	0.486
30 to 39	323 (0.6)	0.09 (0.01 to 0.62)	0.022
40 to 49	1,120 (2.1)	0.1 (0.04 to 0.27)	< 0.001
50 to 54	2,059 (3.9)	0.16 (0.09 to 0.29)	< 0.001
55 to 59	3,908 (7.5)	0.16 (0.1 to 0.24)	< 0.001
60 to 64	5,682 (10.9)	0.26 (0.2 to 0.35)	< 0.001
65 to 74	14,123 (27.1)	0.57 (0.5 to 0.65)	< 0.001
75 to 79	9,399 (17.7)	0.91 (0.81 to 1.03)	0.407
80 +	15,553 (30.0)	2.19 (2.03 to 2.37)	< 0.001
Sex . M;F, n	25,937:26,349		
Mean hospitalization, days (SD)	20.4 (17.9)		
Intensive care therapy, n (%)	13,177/52,286 (25.2)	3.03 (2.82 to 3.27)	< 0.001
Deaths, n (%)	1,804/52,286 (3.5)		

Data are noted in absolute and relative frequencies. For comparison of categorical variables, we used chi-squared test. Statistical significance was considered $p \leq 0.05$. The OR and 95% CI for the in-hospital mortality were calculated.
*Chi-squared test.
CI, confidence interval; OR, odds ratio; SD, standard deviation.

Table II. Absolute and relative frequencies of secondary diagnosis and odds ratios for in-hospital mortality of the 52,286 included patients with periprosthetic joint infection.

Variable	Absolute (relative) frequencies, n (%)	OR (95% CI)	p-value*
Arterial hypertension	27,378 (52.4)	0.84 (0.77 to 0.91)	< 0.001
Oral anticoagulant	9,739 (18.6)	1.52 (1.37 to 1.68)	< 0.001
Diabetes mellitus	8,829 (16.9)	0.98 (0.86 to 1.11)	0.981
Chronic renal insufficiency (KDIGO severity score > III)	6,332 (12.1)	2.11 (1.89 to 2.34)	< 0.001
Atrial fibrillation (paroxysmal)	6,095 (11.7)	2.33 (2.09 to 2.59)	< 0.001
Hyperuricemia	4,395 (8.4)	0.93 (0.79 to 1.11)	0.875
Atrial fibrillation (permanent)	2,756 (5.3)	2.74 (2.39 to 3.15)	< 0.001
Cardiac pacemaker/defibril-lator	2,717 (5.2)	2.59 (2.23 to 3.00)	< 0.001
Obesity (level 1)	2,230 (4.3)	0.5 (0.36 to 0.69)	< 0.001
Obstructive sleep apnea syndrome	2,141 (4.1)	0.71 (0.54 to 0.94)	0.095
Coronary heart disease (three vessels)	1,686 (3.2)	2.55 (2.14 to 3.05)	< 0.001
Obesity (level 2)	1,552 (3.0)	0.59 (0.41 to 0.84)	0.026
Obesity (level 3)	1,385 (2.6)	0.81 (0.59 to 1.12)	0.633
Tendency to fall	1,359 (2.6)	1.00 (0.75 to 1.35)	0.999

Data are noted in absolute and relative frequencies. Statistical significance was considered $p \leq 0.05$. The OR and 95% CI for the in-hospital mortality were calculated.
*Chi-squared test.
CI, confidence interval; KDIGO, Kidney Disease: Improving Global Outcomes; OR, odds ratio.

present in 2,717 patients (5%). The calculation of in-hospital mortality rate of secondary diagnosis revealed the highest OR for permanent atrial fibrillation (OR 2.74; 95% CI 2.39 to 3.15; p < 0.001, all chi-squared test), followed by the presence of a cardiac pacemaker/defibrillator (OR 2.59; 95% CI 2.23 to 3.00; p < 0.001) and three vessel coronary heart disease (OR 2.55; 95% CI 2.14 to 3.05; p < 0.001). Moreover, paroxysmal atrial fibrillation (OR 2.33; CI 2.09 to 2.59, p < 0.001), chronic renal insufficiency (OR 2.11; 95% CI 1.89 to 2.34; p < 0.001), and oral anticoagulation (OR 1.52; 95% CI 1.37 to 1.68; p < 0.001) were associated with a higher in-hospital mortality rate. Common comorbidities, such as hypertension (OR 0.84; 95% CI 0.77 to 0.91; p < 0.001), diabetes mellitus (OR 0.98; 95% CI 0.86 to 1.11; p = 0.981), or obesity level three (OR 0.81; 95% CI 0.59 to 1.12; p = 0.633)[21] did not show a higher risk for in-hospital mortality. However, the result was not statistically significant for diabetes mellitus (Table II and Figure 1).

Risk factors for in-hospital mortality in terms of diagnostic instruments

The use of diagnostic instruments revealed that CT of the skeleton without contrast medium was applied in 3,787 patients (7%), representing the most frequently used diagnostic tool. CT of the pelvis was performed in 2,150 patients (4%) with contrast medium, and in 1,725 patients (3%) without contrast medium. Other diagnostic instruments, such as CT of the chest and the abdomen, were used in 2,385 (4.6%) and 2,309 patients (4.4%), respectively. Special imaging techniques for focus search as ^{18}F-fluorodeoxyglucose Positron emission tomography/CT (^{18}FDG-PET/CT) or single photon emission CT (SPECT/CT) were only rarely performed (in 248 patients (0.5%) and 35 patients (0.1%), respectively), therefore no OR for in-hospital mortality could be calculated. CT of the chest and the abdomen with contrast medium showed the highest ORs for in-hospital mortality (OR 5.22; 95% CI 4.63 to 5.89; p < 0.001) and (OR 5.21; 95% CI 4.60 to 5.89; p < 0.001), respectively. CT of the pelvis with contrast medium, as well as MRI of the spine, was associated with a higher in-hospital mortality (OR 3.92; 95% CI 3.37 to 4.56; p < 0.001) and (OR 3.34; 95% CI 2.37 to 4.71; p < 0.001), respectively (Table III and Figure 2).

Risk factors for in-hospital mortality in terms of complications

Regarding complications, acute bleeding was the one most often diagnosed, being observed in 21,197 patients (40.5%). In 4,419 patients (8%), urinary tract infections were detected. Acute respiratory failure occurred in 2,950 patients (6%). Appearance of wound dehiscence and pleural effusion was present in approximately 1,778 (3.4%) and 1,447 patients (2.8%), respectively. Systemic inflammatory response syndrome (SIRS) was diagnosed in 1,206 patients (2%), while 593 patients (1%) suffered from septic shock syndrome. The evaluation of the in-hospital mortality regarding the complications showed by far the highest OR

Table III. Absolute and relative frequencies of imaging tools and odds ratios for in-hospital mortality of the 52,286 included patients with periprosthetic joint infection.

Variable	Absolute (relative) frequencies, n (%)	OR (95% CI)	p-value*
CT of skeleton (without CM)	3,787 (7.2)	1.83 (1.59 to 2.10)	< 0.001
CT of chest (with CM)	2,385 (4.6)	5.22 (4.63 to 5.89)	< 0.001
CT of head (without CM)	2,309 (4.4)	1.83 (1.59 to 2.10)	< 0.001
CT of belly (with CM)	2,231 (4.3)	5.21 (4.60 to 5.89)	< 0.001
CT of pelvis (without CM)	2,150 (4.1)	2.76 (2.36 to 3.22)	< 0.001
CT of pelvis (with CM)	1,725 (3.3)	3.92 (3.37 to 4.56)	< 0.001
MRI of spine (with CM)	347 (0.7)	3.34 (2.37 to 4.71)	< 0.001
^{18}FDG-PET/CT	248 (0.5)	X†	0.031
Skeletal scintigraphy	231 (0.4)	1.81 (1.05 to 3.11)	0.191
SPECT-CT	35 (0.1)	X†	0.741

Data are noted in absolute and relative frequencies. Statistical significance was considered p ≤ 0.05. The OR and 95% CI for the in-hospital mortality were calculated.
*Chi-squared test.
†Not possible to calculate.
CI, confidence interval; CM, contrast medium; ^{18}FDG-PET/CT, ^{18}F-fluorodeoxyglucose Positron emission tomography/computed tomography; OR, odds ratio; SPECT/CT, single photon emission computed tomography.

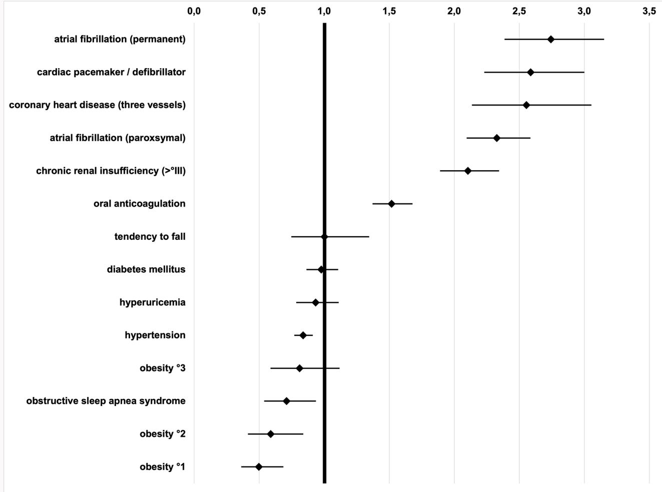

Fig. 1
Odds ratios for secondary diagnosis and in-hospital mortality of the 52,286 included patients.

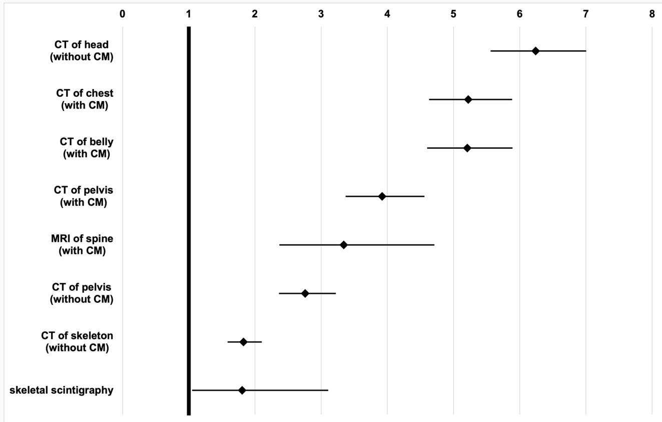

Fig. 2
Odds ratios for imaging tools and in-hospital mortality of the 52,286 included patients.

in association with septic shock syndrome (OR 39.20; 95% CI 33.0 to 46.46; p < 0.001, all chi-squared test) or SIRS (OR 29.51; 95% CI 26.11 too 33.35; p < 0.001). Acute kidney injury (KDIGO severity score ≥ level III) (OR 17.29; 95% CI 15.14 to 19.74; p < 0.001), hospital-acquired pneumonia (OR 11.66; 95% CI 9.96 to 13.65; p < 0.001), pleural effusion (OR 10.99; 5% CI 9.71 to 12.44; p < 0.001), and acute respiratory failure (OR 8.82; 95% CI 8.01 to 9.72; p < 0.001) were associated with a higher in-hospital mortality. Acute anaemia following bleeding and wound dehiscence were also associated with a higher in-hospital mortality (OR 1.72; 95% CI 1.60 to 1.85; p < 0.001 and OR 1.67; 95% CI 1.36 to 2.05; p < 0.001, respectively). However, they showed the lowest OR in comparison to other complications (Table IV and Figure 3).

Discussion

All patients suffering from PJI, who received in-hospital therapy in Germany, were included in this study. Out of those 52,286 patients, 1,804 died, demonstrating an in-house mortality rate of 3.5%. Hypertension, diabetes mellitus, and obesity, the most common comorbidities, were not associated with higher in-hospital mortality. In contrast, cardiac diseases, such as atrial fibrillation, presence of a cardiac pacemaker/defibrillator, or three-vessel coronary heart disease, showed the highest risk for in-hospital mortality. Postoperative anaemia occurred in more than two-thirds of patients and was associated with an increased in-hospital mortality. Severe complications, such as organ failure, SIRS, or septic shock syndrome, showed by far the highest association with in-hospital mortality. CT for focus search or detection of complications was associated with high in-hospital mortality rates.

Risk factors for in-hospital mortality in terms of secondary diagnosis

This epidemiological study revealed an in-hospital mortality rate of 3.5%. The existing literature reports different mortality rates.[17,22] Natusuhara et al[17] performed a database search including 23 studies and 19,169 patients, and found a one-year mortality of 4.22% for patients with PJI of the hip. In another study, Natsuhara et al[3] detected a one-year mortality of 4.33% for PJI of the knee. In contrast, a cohort study of the Danish Hip Arthroplasty register found a one-year mortality of even 8%.[23] However, none of these studies specifically focus on in-hospital mortality. While most of the existing studies focus on detecting risk factors, which predispose to develop a PJI, only a few studies perform research on risk factors for in-hospital mortality in terms of PJI.[15] Banke et al[6] performed a systematic review on the epidemiology and prevention of PJI. They detected diabetes, obesity, immunosuppression, oncological diseases, rheumatoid arthritis, previous chronic infections, and bacteremia as endogenous risk factors for developing a PJI. Another study by Blanco et al[1] focusing on TKA found that obesity

Table IV. Absolute and relative frequencies of complications and odds ratios for in-hospital mortality of the 52,286 included patients with periprosthetic joint infection.

Variable	Absolute (relative) frequencies, n (%)	OR (95% CI)	p-value*
Acute anaemia following bleeding	21,197 (40.5)	1.72 (1.60 to 1.85)	< 0.001
Urinary tract infection	4,419 (8.5)	2.81 (2.51 to 3.14)	< 0.001
Acute respiratory failure	2,950 (5.6)	8.82 (8.01 to 9.72)	< 0.001
Wound dehiscence	1,778 (3.4)	1.67 (1.36 to 2.05)	< 0.001
Pleural effusion	1,447 (2.8)	10.99 (9.71 to 12.44)	< 0.001
Systemic inflammatory response syndrome	1,206 (2.3)	29.51 (26.11 to 33.35)	< 0.001
Acute kidney injury (KDIGO ≥ °3)	1,058 (2.0)	17.29 (15.14 to 19.74)	< 0.001
Hospital-acquired pneumonia	816 (1.6)	11.66 (9.96 to 13.65)	< 0.001
Septic shock	593 (1.1)	39.20 (33.07 to 46.46)	< 0.001

Data are noted in absolute and relative frequencies. Statistical significance was considered $p \leq 0.05$. The OR and 95% CI for the in-hospital mortality were calculated.
*Chi-squared test.
CI, confidence interval; OR, odds ratio.

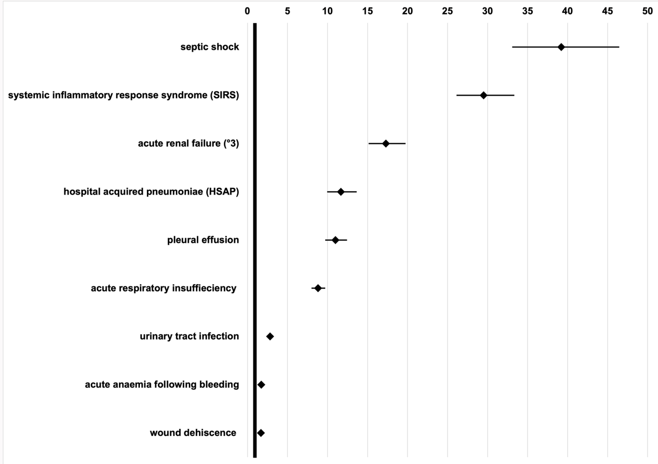

Fig. 3
Odds ratios for complications and in-hospital mortality of the 52,286 included patients.

(BMI > 30 kg/m^2), diabetes mellitus, high American Society of Anesthesiologists grade (> III),[24] and the need for blood transfusion were associated with PJI. Our data showed comparable results, revealing hypertension, oral anticoagulation, and diabetes mellitus as the most common secondary diagnoses. However, we could demonstrate that some of the most common secondary diagnoses, such as hypertension, diabetes mellitus, or obesity, were not associated with an increased risk of in-hospital mortality. Nevertheless, it is of utmost importance to minimize these risk factors preoperatively.[3,6] Hyperuricemia, obstructive sleep apnea syndrome, and an increased risk of falling were neither associated with a higher in-hospital mortality. This observation is in line with the findings of Shahi et al.[15] Our data revealed permanent atrial fibrillation, as well as the presence of a cardiac pacemaker/defibrillator and three-vessel coronary heart disease, to be associated with the highest risk of in-hospital mortality. In addition, chronic kidney disease and medication with oral anticoagulation showed an increased risk for in-hospital mortality. Bozic et al,[25] who investigated risk factors for 90-day postoperative mortality after TKA, also described comparable results. They identified congestive heart failure, metastatic cancer, renal insufficiency, peripheral vascular disease, cerebrovascular disease, lymphoma, cardiac arrythmia, dementia, pulmonary circulation disorders, and chronic liver disease as independent risk factors. In relation to high in-hospital mortality for patients with cardiac comorbidities, such as atrial fibrillation or three-vessel cardiac disease, this cohort in particular should be treated with special care. Especially in those patients, risk factors should be optimized preoperatively, and anticoagulant therapy stopped and restarted on time. Furthermore, interdisciplinary treatment by specialists in internal medicine (e.g. cardiology) might be beneficial for pre- and postoperative optimization.

Risk factors for in-hospital mortality in terms of diagnostic instruments

The evaluation of diagnostic tools, which were used in patients with PJI, revealed that CT of the skeleton without contrast medium was most often performed. This finding is in line with the present literature. The main primary imaging tool is standardized radiographs, which might be followed by CT to distinguish between septic and aseptic loosening.[26] However, CT of the chest, abdomen, and pelvis with contrast medium, as well as MRI of the spine with contrast medium, were associated with the highest in-hospital mortality. One explanation may be the search for in-hospital complications, such as pulmonary embolism or mesenteric ischaemia. Another reason might be the intention to detect further infection foci in terms of PJI as pneumonia, psoas abscess, or spondylodiscitis. Although execution of these diagnostic instruments is associated with a higher in-hospital mortality, they do not demonstrate an actual risk factor themselves. However, their usage reflects a quite vulnerable patient cohort that should be treated with special care and liberally receive early intensive care therapy. Especially in combination with other risk factors, such as age above 80 years or cardiac diseases, the in-hospital mortality should not be underestimated. Over recent years, nuclear medical diagnostic tools, such as ^{18}FDG-PET/CT, skeletal scintigraphy, and SPECT-CT, have gained growing importance in terms of detection of further infection foci.[27,28] However, the present data demonstrate that these diagnostic instruments are still rarely used; a reason might be their limited availability, being accessible only at maximum care hospitals.

Risk factors for in-hospital mortality in terms of complications

Regarding complications, the need for intensive care therapy was associated with a higher in-hospital mortality. This observation is also described by Pöll et al,[11] who analyzed risk factors and the outcome of patients with PJI who were admitted to an intensive care unit. Like the imaging tools, intensive care therapy itself is not a risk factor, though those patients who need intensive care therapy demonstrate a more vulnerable cohort. The most frequent complication was acute anaemia following bleeding, being associated with a slightly increased in-hospital mortality. This emphasizes the role of sufficient perioperative blood management. Organ failure, SIRS, and septic shock syndrome had the highest association with in-hospital mortality. These findings are in line with Tokarski et al,[29] who found higher in-hospital mortality in case of a systemic manifestation of PJI, and highlight the vulnerability of this cohort. In our opinion, it is crucial to be wary of the threat of PJI; the treating orthopaedic surgeon should highlight the significant increased risk of death, which goes along with a possible PJI, in the preoperative discussion with the patient.

Limitation and strengths

The main limitation of the present study demonstrates its retrospective study design using anonymized data of a big database. Therefore, it was not possible to conduct further statistical analysis as logistical regression. Moreover, it was not possible to detect the actual diagnosis, which led to death, to perform an analysis on germs or a comparison of surgical procedures. The InEK browser only enables data from 1 January 2019 onwards and no previous timepoint. Nevertheless, it constitutes the biggest database in Europe, and every hospital in Germany is obliged to provide their data. The correct coding of diagnosis can be assumed, since DRG lump sum payment relies on it. This is strictly controlled by the Medical Service of Health Funds, a facility run by the statutory health insurance fund in Germany. Although the provided data only incorporate the in-hospital treatment and no further follow-up, the main strength of the study demonstrates the fact that almost every diagnosed PJI between 1 January 2019 and 31 December 2022 in Germany is enrolled. As a PJI demonstrates a severe complication after TJR, this complication is almost never treated ambulatory.

In conclusion, revealing an in-hospital mortality of 3.5%, this cross-sectional, epidemiological study highlights the threat of PJI. A systemic manifestation of PJI with multi-organ failure, SIRS, or septic shock syndrome corresponds with very high rates of in-hospital mortality. Keeping this in mind, PJI should not be underestimated, and patients should liberally receive early intensive care therapy. Although the most common comorbidities, such as diabetes, hypertension, or obesity, predispose to development of a PJI, they were not associated with a higher in-hospital mortality. In contrast, patients with cardiac comorbidities, such as atrial fibrillation or three-vessel cardiac disease, showed an increased in-hospital mortality. In this cohort, risk factors should be optimized preoperatively, and anticoagulant therapy stopped and restarted on time.

The high frequency of acute anaemia following bleeding and its increased mortality highlights the importance of sufficient patient blood management. Furthermore, interdisciplinary treatment by specialists in internal medicine (e.g. cardiology) might be beneficial for pre- and postoperative optimization.

References

1. **Blanco JF**, **Díaz A**, **Melchor FR**, **da Casa C**, **Pescador D**. Risk factors for periprosthetic joint infection after total knee arthroplasty. *Arch Orthop Trauma Surg*. 2020;140(2):239–245.
2. **Kapadia BH**, **Berg RA**, **Daley JA**, **Fritz J**, **Bhave A**, **Mont MA**. Periprosthetic joint infection. *Lancet*. 2016;387(10016):386–394.
3. **Natsuhara KM**, **Shelton TJ**, **Meehan JP**, **Lum ZC**. Mortality during total hip periprosthetic joint infection. *J Arthroplasty*. 2019;34(7S):S337–S342.
4. **Yapp LZ**, **Clement ND**, **Moran M**, **Clarke JV**, **Simpson A**, **Scott CEH**. Long-term mortality rates and associated risk factors following primary and revision knee arthroplasty: 107,121 patients from the Scottish Arthroplasty Project. *Bone Joint J*. 2022;104-B(1):45–52.
5. **Li C**, **Renz N**, **Trampuz A**. Management of periprosthetic joint infection. *Hip Pelvis*. 2018;30(3):138–146.
6. **Banke IJ**, **von Eisenhart-Rothe R**, **Mühlhofer HML**. Epidemiology and prevention of prosthetic joint infection. *Orthopade*. 2015;44(12):928.
7. **Premkumar A**, **Kolin DA**, **Farley KX**, **et al**. Projected economic burden of periprosthetic joint infection of the hip and knee in the United States. *J Arthroplasty*. 2021;36(5):1484–1489.
8. **Learmonth ID**, **Young C**, **Rorabeck C**. The operation of the century: total hip replacement. *Lancet*. 2007;370(9597):1508–1519.
9. **Singh JA**, **Yu S**, **Chen L**, **Cleveland JD**. Rates of total joint replacement in the United States: future projections to 2020–2040 using the national inpatient sample. *J Rheumatol*. 2019;46(9):1134–1140.
10. **Rupp M**, **Lau E**, **Kurtz SM**, **Alt V**. Projections of primary TKA and THA in Germany from 2016 through 2040. *Clin Orthop Relat Res*. 2020;478(7):1622–1633.
11. **Pöll AM**, **Baecker H**, **Yilmaz E**, **et al**. Risk factors and outcome of patients with periprosthetic joint infection admitted to intensive care unit. *Arch Orthop Trauma Surg*. 2020;140(8):1081–1085.
12. **Szymski D**, **Walter N**, **Alt V**, **Rupp M**. Evaluation of comorbidities as risk factors for fracture-related infection and periprosthetic joint infection in Germany. *J Clin Med*. 2022;11(17):17.
13. **Ross JJ**. Septic arthritis of native joints. *Infect Dis Clin North Am*. 2017;31(2):203–218.
14. **Patel KM**, **Mears SC**, **Barnes CL**, **Stambough JB**, **Stronach BM**. Sepsis and total joint arthroplasty. *Orthop Clin North Am*. 2022;53(1):13–24.
15. **Shahi A**, **Tan TL**, **Chen AF**, **Maltenfort MG**, **Parvizi J**. In-hospital mortality in patients with periprosthetic joint infection. *J Arthroplasty*. 2017;32(3):948–952.
16. **Walter N**, **Rupp M**, **Hinterberger T**, **Alt V**. Prosthetic infections and the increasing importance of psychological comorbidities: an epidemiological analysis for Germany from 2009 through 2019. *Orthopade*. 2021;50(10):859–865.
17. **Natsuhara KM**, **Shelton TJ**, **Meehan JP**, **Lum ZC**. Mortality during total hip periprosthetic joint infection. *J Arthroplasty*. 2019;34(7S):S337–S342.
18. **No authors listed**. International Statistical Classification of Diseases and Related Health Problems, 10th Revision, German Modification, Version 2024. https://klassifikationen.bfarm.de/icd-10-gm/kode-suche/htmlgm2024/index.htm (date last accessed 15 April 2024).
19. **No authors listed**. The Institute for the Remuneration System in Hospitals (InEK) data browser. https://datenbrowser.inek.org/ (date last accessed 22 March 2024).
20. **Khwaja A**. KDIGO clinical practice guidelines for acute kidney injury. *Nephron Clin Pract*. 2012;120(4):c179–c184.
21. **No authors listed**. Obesity classification. World Obesity. https://www.worldobesity.org/about/about-obesity/obesity-classification (date last accessed 15 April 2024).
22. **Zmistowski B**, **Karam JA**, **Durinka JB**, **Casper DS**, **Parvizi J**. Periprosthetic joint infection increases the risk of one-year mortality. *J Bone Joint Surg Am*. 2013;95-A(24):2177–2184.
23. **Gundtoft PH**, **Pedersen AB**, **Varnum C**, **Overgaard S**. Increased mortality after prosthetic joint infection in primary THA. *Clin Orthop Relat Res*. 2017;475(11):2623–2631.
24. **Saklad M**. Grading of patients for surgical procedures. *Anesthesiol*. 1941;2(3):281–284.
25. **Bozic KJ**, **Lau E**, **Kurtz S**, **Ong K**, **Berry DJ**. Patient-related risk factors for postoperative mortality and periprosthetic joint infection in medicare patients undergoing TKA. *Clin Orthop Relat Res*. 2012;470(1):130–137.
26. **Lima ALL**, **Oliveira PR**, **Carvalho VC**, **Saconi ES**, **Cabrita HB**, **Rodrigues MB**. Periprosthetic joint infections. *Interdiscip Perspect Infect Dis*. 2013;2013:542796.

27. **Kim K**, **Kim SJ**. Diagnostic role of PET or PET/CT for prosthetic joint infection: a systematic review and meta-analysis. *Hell J Nucl Med*. 2021;24(1):83–93.
28. **Casali M**, **Lauri C**, **Altini C**, **et al**. State of the art of ^{18}F-FDG PET/CT application in inflammation and infection: a guide for image acquisition and interpretation. *Clin Transl Imaging*. 2021;9(4):299–339.
29. **Tokarski A**, **Courtney PM**, **Deirmengian C**, **Kwan S**, **McCahon J**, **Deirmengian GK**. Systemic manifestation of periprosthetic joint infection is associated with increased in-hospital mortality. *Cureus*. 2023;15(3):e36572.

Author information

J. Reinhard, MD, Chief Resident,
Department of Orthopaedic Surgery, University Medical Center Regensburg, Regensburg, Germany;
Department of Trauma Surgery, University Medical Center Regensburg, Regensburg, Germany.

S. Lang, MD, Chief Resident
N. Walter, PhD, Research Associate
M. Schindler, MD, Resident
D. Szymski, MD, Resident
V. Alt, MD, PhD, Head of Department
M. Rupp, MD, Senior Doctor
Department of Trauma Surgery, University Medical Center Regensburg, Regensburg, Germany.

S. Bärtl, MD, Resident, Department of Trauma Surgery, University Medical Center Regensburg, Regensburg, Germany; Center for Musculoskeletal Surgery, Charité – University Medicine Berlin, Berlin, Germany.

Author contributions

J. Reinhard: Conceptualization, Investigation, Validation, Writing – original draft, Writing – review & editing.
S. Lang: Conceptualization, Investigation, Validation, Writing – original draft, Writing – review & editing.
N. Walter: Data curation, Formal analysis, Writing – review & editing.
M. Schindler: Data curation, Formal analysis, Writing – review & editing.
S. Bärtl: Data curation, Formal analysis, Writing – review & editing.
D. Szymski: Data curation, Formal analysis, Writing – review & editing.
V. Alt: Conceptualization, Data curation, Formal analysis, Writing – review & editing.
M. Rupp: Conceptualization, Data curation, Formal analysis, Writing – review & editing.

Funding statement

The authors received no financial or material support for the research, authorship, and/or publication of this article.

ICMJE COI statement

The authors confirm that there are no conflicts of interest in the publication of this article.

Data sharing

The data that support the findings for this study are available to other researchers from the corresponding author upon reasonable request.

Ethical review statement

Due to the fact, only anonymized data from a central, administrative database was used, no informed consent and Investigational Review Board approval was needed.

Open access funding

The authors report that the open access funding for this manuscript was self-funded.

Trial registration number

As the study only used anonymized data from an administrative, central database, neither informed consent or Institutional Review Board approval was required.