Nosocomial infection

Surveillance of surgical site infections in orthopedic prosthetic surgery: a tool for identifying risk factors and improving clinical practice

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Keywords

Surgical Site Infection • Knee and Hip prosthesis • Antimicrobial prophylaxis

Summary

Introduction. *Surgical site infections (SSIs) are among the most frequently encountered complications in prosthetic surgery, and are associated with increased hospitalization, costs and in-hospital mortality. There is no national system for the comprehensive monitoring of the incidence of SSIs.*

Methods. *All patients undergoing orthopedic prosthetic surgery from April 1 to June 30, 2023 were enrolled. Clinical evaluation of the surgical site was conducted at 30 days, and a follow-up telephone interview was carried out by means of a specially designed questionnaire at 90 days.*

Results. *A total of 59 patients were included. Surgery was performed on the knee in 71.19% and on the hip in 28.81%. The patients' mean BMI was 28.25 ± 2.97, and their mean ASA score was 2.67 ± 0.58. Six patients had diabetes mellitus. The incidence of SSIs was 5.08%; two infections occurred in knee prosthesis surgery and one in hip surgery. Analysis of the data revealed that diabetes was the main risk factor for the development of infection.*

Conclusions. *Although based on a small number of patients, these results are encouraging, especially considering that the patients had an average ASA score of more than 2 and a high BMI. However, to further reduce the risk of infection, improved hygiene measures have now been implemented in the operating room and the antibiotic prophylaxis protocol has been updated to take into account the potential for MRSA colonization.*

Introduction

Surgical site infections (SSIs) are among the most frequent complications arising from medical care. These infections result in a significant increase in hospitalization duration, costs and mortality [1].

Given their potentially devastating consequences [3], postoperative infections constitute highly serious events, both for the individual patient and for society [2]. The treatment of such infections often involves prolonged hospitalization, the use of targeted, sometimes prolonged, antibiotic treatments and, in many instances, additional surgical procedures. The implications of all this, in terms of the patient's prognosis and healthcare costs, are evident [3].

The infection rate after prosthetic knee surgery ranges from approximately 0.8 to 1.9%, while for total hip prostheses, infection rates are between 0.3 and 1.7% [4]. A different scenario emerges in the case of infections associated with osteosynthesis devices, with incidence rates varying from 1-2% for closed fractures to 30% or more for open fractures [4]. Moreover, mortality in elderly patients with prosthetic infections is estimated to be around 5-10% [4].

The contamination of joint prostheses results from an intricate interplay between bacterial elements, prostheses and host-related factors. Various bacteria adhere to prosthetic material in several ways, and adhesion is influenced by the type of material employed and the smoothness of its surface [3].

Bacterial infections may occur early through direct contamination of prostheses during surgical procedures and/or diffusion from surrounding areas, or later, through hematogenous spread from other foci (20-30%) [3]. Prostheses can be contaminated directly during surgery if pathogens are present in the operating room, on the patient's skin, or on medical staff. Hematogenous sources of infection include skin ulcerations, periodontal infections, and bacteremias from urological procedures. Late infections arise after the first year post-surgery and are often due to hematogenous infections from other foci or skin lesions. These latter infections are more difficult to diagnose, owing to their less evident clinical presentation [3].

Coagulase-negative Staphylococci (CoNS) are the microorganisms most frequently involved in prosthetic infections, with S. epidermidis and S. aureus being predominant in early infections and other bacterial species in late infections. Anaerobic bacteria are less frequently responsible for these infections, and fungal and mycobacterial infections are even less frequent [3].

Risk factors for the development of prosthetic infections can be categorized in three groups: 1) host-related

factors (including advanced age, uncontrolled diabetes, neoplasms, rheumatoid arthritis, sickle cell anemia and previous joint replacement procedures); 2) intraoperative factors (including the use of large prostheses, hematoma formation in the surgical wound and poorly aligned skin incisions); 3) postoperative factors (including the spread of infections from other sites or the presence of skin ulcers) [3].

The implementation of intervention programs reduces the risk of SSIs. Indeed, such programs continue to be a prominent focus in the surveillance of healthcare-associated infections in Europe. The ECDC initiated SSI surveillance in July 2008. In Italy, the National Surgical Site Infection Surveillance System (SNICh) utilizes voluntary participation by regional authorities and healthcare institutions in order to gather epidemiological data, which are then transmitted to the ECDC. The primary goal of SSI surveillance is to standardize data collection, thereby promoting comparability among participating operational units and institutions at the regional, national and international levels [1].

Methods

From April 1, 2023, to June 30, 2023, we enrolled patients in a prospective study on surgical site surveillance in prosthetic surgery. The surgical site was inspected on the 30th day after the procedure. As part of surgical site infection surveillance, a telephone interview was conducted after 90 days by means of a specially formulated questionnaire. The questionnaire was designed to take into account the epidemiological surveillance needs of the hospital's surgical setting, according to the items in Table I.

Statistical analysis

All characteristics were expressed as means with standard deviations, medians and ranges for continuous variables, and, for categorical variables, as absolute values and percentages. As the data did not display a normal distribution, every possible numerical transformation of the data was evaluated. As none of these transformations was able to reduce the effect of skewness, the data were analyzed by means of non-parametric tests. The Kruskal-Wallis test was used to compare means, while the Chi-square test was used to assess independence between variables. All tests were two-sided, and a p-value of less than 0.05 was considered statistically significant. All statistical analyses were performed by means of Stata/SE 14.2 software (StataCorp LP, College Station, TX, USA).

Results

A total of 59 patients, with an average age of 74 ± 8 years (median 75, range 53-90), were enrolled in the study. Of these, 42 (71.19%) were women. The average BMI of the patients enrolled was 28.56 ± 4.52 (median 28.68, range 18.65-38.80).

Tab. I. Demographic and surveillance characteristics.

Age	
Gender	
Type of discharge	Alive or deceased in hospital
Type of surgery	Hip or knee
Date of surgery	
ASA classification	
BMI	
Comorbidity	Diabetes, COPD, hypertension
Cigarette smoking	
Antibiotics	Type of antibiotics, time of administration
Hair removal	Clipper or razor
Skin preparation	2% chlorhexidine gluconate (CHG) in 70% isopropyl alcohol antiseptic solution
Perioperative glucose monitoring	
Number of operators in the operating room	
Procedure duration	
Surgical site infection	Date and microorganism
MRSA Surveillance	Nasal swab

ASA: American Society of Anesthesiologists; BMI: body mass index; MRSA: methicillin-resistant staphylococcus aureus; COPD: Chronic obstructive pulmonary disease.

Concerning the types of prosthetic procedures, 42 patients (71.19%) underwent knee prosthesis surgery, which was performed by means of either traditional or robotic techniques, while 17 (28.81%) underwent hip prosthesis surgery (Tab. II). All hip prosthesis procedures were conducted by means of traditional surgical methods, whereas 52.38% of knee prosthesis procedures (22 patients) utilized robotic techniques, and 47.62% (20 patients) employed traditional surgical approaches. Patient classification according to the American Society of Anesthesiologists (ASA) revealed that 34 patients (57.63%) were classified as ASA 2, and 42.37% (25 patients) as ASA 3 (Tab. II). Regarding comorbidities, 10.17% (6 patients) had a history of diabetes. Only one patient had nasal colonization with MRSA, and was treated with mupirocin before surgery [5].

Surgical prophylaxis during the procedures involved the administration of cefazolin in 69.49% (41 patients), levofloxacin plus teicoplanin in 27.12% (16 patients), and teicoplanin alone in 3.39% (2 patients). The median number of operators present in the operating room was 6. The mean duration of the procedures was 98.29 ± 23.05 minutes, with a median of 94 (85-116) minutes, and the average length of hospital stay was 6.39 ± 3.23 days, with a median of 5 (4-8) days.

Only three patients (5.08%) developed an infection; specifically, two infections occurred in knee prosthesis procedures (4.76%) both after robotic surgery, and one after hip prosthesis surgery (5.9%)

The average age of patients who developed an SSI was 76.33 ± 5.03 years, with a mean BMI of 28.25 ± 2.97 and an ASA score of 2.67 ± 0.58. The mean duration of

Tab. II. Characteristics of patients and procedures.

		% (N°)
Type of surgery	Mako robotic arm-assisted	37.29% (22)
	Non-robotic	62.71% (37)
Type of prosthesis	Hip	28.81% (17)
	Knee	71.19% (42)
Diabetes	Yes	10.17% (6)
	No	89.83% (53)
N. operating room operators	5	28.81% (17)
	6	52.54% (31)
	7	10.17% (6)
	8	5.09% (3)
	9	3.39% (2)
Surgical prophylaxis	Cefazolin	69.49% (41)
	Levofloxacin plus teicoplanin	27.12% (16)
	Only teicoplanin	3.39% (2)
Trichotomy	No	5.08% (3)
	Yes	94.92% (56)
ASA score	2	57.63% (34)
	3	42.37% (25)

Tab. III. Patient- and procedure-related features.

	SSIs	No SSI	p
Age (years)	76.33 ± 5.03	74.12 ± 7.81	NS
BMI	28.25 ± 2.97	28.58 ± 4.61	NS
Procedure duration (min)	97.67 ± 11.24	98.32 ± 23.58	NS
Hospital stay (days)	10.33 ± 6.11	6.18 ± 2.95	NS
ASA score	2.67 ± 0.58	2.41 ± 0.50	NS
Number of operators in operating room	6.33 ± 0.58	6 ± 0.97	NS

NS: not significant.

procedures was 97.67 ± 11.24 minutes, and an average of 6.33 ± 0.58 operators were present in the operating room. The average length of hospital stay of those with SSI was 10.33 ± 6.11 days (Tab. III).

Regarding risk factors, only diabetes was found to be significantly associated with the risk of developing a Healthcare-Associated Infection (Tab. IV). Furthermore, analysis of the relationship between the number of operators in the operating room and the risk of developing an SSI revealed an odds ratio (OR) of 1.44 (95% CI 0.43-4.86) for each additional operator present; however, this association was not statistically significant.

Demographic characteristics and intrinsic and extrinsic risk factors were evaluated for each patient who developed an SSI.

Patient 1: a man 71-year-old underwent hip prosthesis surgery; the procedure lasted 95 minutes and a maximum of 7 operators were simultaneously present in the operating room. The patient's risk factors were: ASA 3, BMI 31.47 and impaired glucose tolerance. He was hospitalized for 9 days; 28 days post-surgery, he developed an early infection according to current definitions, caused by Methicillin-Resistant Staphylococcus epidermidis (MRSE).

Patient 2: a man 81-year-old underwent knee prosthesis surgery; the procedure lasted 88 minutes and a maximum of 6 operators were simultaneously present in the operating room. The patient's risk factors were: ASA 2, BMI 27.68 and diabetes. He was hospitalized for 5 days and developed an early infection without culture isolation 3 days post-surgery.

Patient 3: a man 77-year-old patient underwent knee prosthesis surgery; the procedure lasted 110 minutes and a maximum of 6 operators were simultaneously present in the operating room. The patient's risk factors were: ASA 3, BMI 25.6. He was hospitalized for 17 days and developed an MRSE infection 27 days post-surgery.

All three patients had received prophylactic cefazolin, with correct timing and dose.

Discussion

Post-surgical infections in orthopedic prosthetic surgery carry serious disabling sequelae for the patient. Moreover, their treatment often necessitates re-operation or prolonged antibiotic therapy, with a potential impact on the onset of microbial resistance, and increases hospitalization costs. For these reasons, surveillance programs have been introduced into clinical practice, at both local and national levels. Indeed, SSI surveillance improves the quality of care, as it reduces the risk of infection [6]. In the SENIC

Tab. IV. Patient- and procedure-related risk factors.

		No SSI	Yes SSI	p
Type of surgery	Mako robotic arm-assisted	90.91% (20)	9.09% (2)	NS
	Open	97.30% (36)	2.70% (1)	
Site of surgery	Hip	94.12% (16)	5.88% (1)	NS
	Knee	95.24% (40)	4.76% (2)	
Diabetes	Yes	66.67% (4)	33.33% (1)	< 0.001
	No	98.11% (52)	1.89% (2)	
Antibiotic prophylaxis	Cefazolin	92.68% (38)	7.32% (3)	NS
	Levofloxacin + teicoplanin	100% (16)	0	
	Only teicoplanin	100% (2)	0	
Trichotomy	No	100% (3)	0	NS
	Yes (hair removal cream)	94.64% (53)	5.36% (3)	

NS: not significant.

study, for instance, SSI surveillance programs, combined with a control and feedback program for surgeons, were found to be associated with a reduction in the incidence of SSIs [7]. Moreover, a systematic literature review suggested that participating in a surveillance program could improve patient outcomes by reducing SSIs; this may be due either to a "surveillance effect" or to the implementation of evidenced - based practice aimed at preventing SSIs [8].

The Surgical Site Infections Surveillance Service in the United Kingdom reported the chronological development of SSIs from surgery to infection over a maximum one-year monitoring period [9]. In the years 2010/2011 1,221 infections detected in 72,000 patients who had undergone hip and knee replacement procedures.

Of the 1,221 infections detected in 72,000 patients who had undergone hip and knee replacement procedures in 2010/11 on considering inpatient monitoring, readmissions and post-discharge follow-up, most infections (85%) were manifested within 30 days following surgery, with an average time to infection of 14 days [9]. Of these infections 42% were labeled as superficial, 43% as deep incisional, and 15% as organ/space infections, with occurrences of superficial incisional infections being documented only within 30 days post-surgery [9].

Data from an observational study conducted in California on 25 patients who experienced an infection after hip surgery between March 2001 and December 2002 showed that referrals owing to a diagnosis of infection after total hip arthroplasty significantly increased over five years ($p = 0.0083$), while rates of non-infection-related revisions remained steady ($p = 0.3910$) [10]. Deep infection, which is a severe complication, occurred in about 0.5 to 3% of primary total hip arthroplasties and in 4 to 6% of revisions [10].

SSI prevention includes a set of actions that are implemented during the preoperative, intraoperative and postoperative phases. In our case series, all patients underwent preoperative hair removal with depilatory cream, and in all the procedures observed, 2% chlorhexidine gluconate in 70% isopropyl alcohol [11] in single-dose dispensers was used as an antiseptic for skin preparation immediately before surgery (evidence 1A).

To date, no specific risk factors for the onset of SSIs in prosthetic surgery have been identified in the literature. Among the various risk factors described in the literature, with regard to the preoperative phase, we considered the ASA score, BMI, diabetes, immunosuppressive therapies, trichotomy (performed or not), nasal carriage of methicillin-resistant Staphylococcus aureus (MRSA), and blood glucose control. Concerning the intraoperative phase, we considered the administration of perioperative prophylaxis at appropriate times and in appropriate ways, the duration of surgery, and the number of operators present in the operating room. The only factor that proved to be significantly associated with SSIs was diabetes, the impact of which was greater than that of BMI or ASA score. This evidence is even more crucial in clinical practice, and emphasizes the need for intensive monitoring of blood glucose levels, both preoperatively and postoperatively, in order to keep blood glucose below 140 mg/dL. Monitoring should be consistently performed, even in non-diabetic patients. Unfortunately, however, monitoring is not consistently performed, even in diabetic patients

Conclusions

In our study, surveillance of surgical site infections enabled us to identify only one risk factor that significantly impacted the development of postoperative infections, namely the presence of diabetes. In the three patients who developed an infection, blood glucose levels were not intensively controlled in the perioperative period, and in only one case was blood glucose tested before the procedure; the value recorded was 184 mg/dL, which is well above the recommended cutoff. Once orthopedic surgeons had been informed of our findings, glycemia testing was routinely undertaken in both diabetic and non-diabetic patients. This adjustment to evidence-based practice was made possible only through active and prospective surveillance, which highlights the importance of such surveillance not only in numerical terms but also in terms of clinical impact. In the coming year, we plan to enroll further patients, in order to assess their outcomes and adherence to the newly implemented measure and to evaluate the impact of this measure on the incidence of infections.

Conflict of interest statement

The authors declare no conflict of interest.

Authors' contributions

All authors contributed to the writing of the manuscript. Data collection: MP, SB. Statistical analysis: MS.

References

[1] Bandini L, D'Ancona F, Creti R, Ricchizzi E, Moro ML, Gagliotti C, Vecchi E, Fabbri E, Cavazzuti L, Tedeschi S. Protocollo Sorveglianza Nazionale delle Infezioni del sito chirurgico (SNICh2) e indicatori di prevenzione negli Ospedali. (versione 1.0 - 12 ottobre 2022). Documento tecnico 0050406-15/12/2022-DGPRE-DGPRE-P.

[2] Romanini E, Tucci G, Zanoli G, Ascione T, Balato G, Baldini A, Borre S, Capanna R, Da Rin De Lorenzo F, Drago L, Falez F, Fantoni M, Galluccio P, Maccauro G, Macri E, Marsella L.T, Meani E, Molendini L.O, Momoli A, Mongardi M, Mugnaini M, Nocco L, Pellegrini A.V, Piccioli A, Riccio G, Romano C, Salomone C, Sandrone C, Schiavone Panni A, Sciortino R, Sessa G, Tarantino U, Tartaglia R, Venditti M, Zagra L, Pavan L. Linee Guida SIOT: prevenzione delle infezioni in chirurgia ortopedica - SISTEMA NAZIONALE LINEE GUIDA DELL'ISTITUTO SUPERIORE DI SANITÀ- Società Italiana di Ortopedia e Traumatologia. 21 maggio 2021. Available at: https://siot.it/wp-content/uploads/2021/06/LG-366-SIOT-Prevenzio-

ne-delle-infezioni-in-chirurgia-ortopedica.pdf (Accessed on 06/12/2023).

[3] Lazzarini L, de Lalla F. Treatment and prevention of prosthetic joint infections. Trends Med 2003;3:75-82. Pharma Project Group srl.

[4] AMCLI ETS. Percorso Diagnostico Le infezioni di protesi articolari e mezzi di osteosintesi. - Rif. 2023-14, rev. 2023. Available at: https://www.amcli.it/wp-content/uploads/2023/05/14_PD-protesi_def16mag2023-tabelle-def.pdf (Accessed on: 06/12/2023).

[5] Borchardt RA, Tzizik D. Update on surgical site infections: The new CDC guidelines. JAAPA 2018;31:524. https://doi.org/10.1097/01.JAA.0000531052.82007.42.

[6] Marchi M, Pan A, Gagliotti C, Morsillo F, Parenti M, Resi D, Moro ML; Sorveglianza Nazionale Infezioni in Chirurgia (SNICh) Study Group. The Italian national surgical site infection surveillance programme and its positive impact, 2009 to 2011. Euro Surveill 2014;19:20815. https://doi.org/10.2807/1560-7917.es2014.19.21.20815.

[7] Hughes JM. Study on the efficacy of nosocomial infection control (SENIC Project): results and implications for the future. Chemotherapy 1988;34:553-61. https://doi.org/10.1159/000238624.

[8] Abbas M, Tartari E, Allegranzi B, Pittet D, Harbarth S. The Effect of participating in a Surgical Site Infection (SSI) Surveillance Network on the time trend of SSI rates: a systematic review. Infect Control Hosp Epidemiol 2017;38:1364-6. https://doi.org/10.1017/ice.2017.186.

[9] Lamagni T. Epidemiology and burden of prosthetic joint infections. J Antimicrob Chemother 2014;69(Suppl 1):i5-10. https://doi.org/10.1093/jac/dku247.

[10] Bozic KJ, Ries MD. The impact of infection after total hip arthroplasty on hospital and surgeon resource utilization. J Bone Joint Surg Am 2005;87:1746-51. https://doi.org/10.2106/JBJS.D.02937.

[11] Darouiche RO, Wall MJ Jr, Itani KM, Otterson MF, Webb AL, Carrick MM, Miller HJ, Awad SS, Crosby CT, Mosier MC, Alsharif A, Berger DH. Chlorhexidine-alcohol versus povidone-iodine for surgical-site antisepsis. N Engl J Med 2010;362:18-26. https://doi.org/10.1056/NEJMoa0810988.

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