Surgical Site Infections in orthopaedic patients – a 10-year retrospective observational study in a Polish hospital

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Abstract

INTRODUCTION Surgical site infections (SSIs) are among the most common healthcare-associated infections. They are associated with longer post-operative hospital stays, additional surgical procedures, treatment in intensive care units and higher mortality.

MATERIAL AND METHODS Surgical site infections (SSIs) were detected in patients hospitalized in a 40-bed orthopaedics ward via continuous surveillance in 2009-2018. The total number of study patients was 15,678. The results were divided into two 5-year periods before and after the introduction of the SSI prevention plan. The study was conducted as part of a national healthcare-Associated Infections surveillance programme, following the methodology recommended by the HAI-Net, European Centre for Disease Prevention and Control Program (ECDC).

RESULTS 168 SSIs were detected in total, including 163 deep SSIs (SSI-D). The total SSI incidence rate was 1.1%, but in hip prosthesis: 1.2%, in knee prosthesis: 1.3%, for open reduction of fracture (FX): 1.3%, for close reduction of fracture (CR): 1.5%, and 0.8% for other procedures. 64% of SSI-D cases required rehospitalisation. A significantly reduction in incidence was found only after fracture reductions: FX and CR, respectively 2.1% vs. 0.7% (OR 3.1 95%CI 1.4-6.6, p<0.01) and 2.1 vs. 0.8% (OR 2.4 95%CI 1.0-5.9, p<0.05). SSI-Ds were usually caused by Gram-positive cocci, specially Staphylococcus aureus, 74 (45.7%); Enterobacteriaceae bacillis accounted for 14.1% and Gram-negative non-fermenting rods for 8.5%.

CONCLUSIONS The implemented SSI prevention plan demonstrated a significant decrease (about 2.5-3 times) in SSI-D incidence in fracture reductions. Depending on the epidemiological situation in the ward, it is worthwhile to surveillance of SSIs
associated to different types of orthopaedic surgery to assess the risks and take preventive measures.

INTRODUCTION

In the European Union, there is a great diversity with regard to the practices of control and employment of staff for infection control teams. In many countries, infection surveillance programmes struggle with human resource shortages and strong local cultural conditions [1]. Poland is one of the Central and Eastern European countries and it was only after the political transformation in 1989 that it began to implement a system of surveillance of healthcare-associated infections (HAIs). Prior to that, either at the national or at the acute health care facility levels, there were no organizational structures or mechanisms allowing to detect, qualify or prevent HAIs; and any attempts to start debating this issue in the public sphere that were undertaken by a few NGOs ended in failure. Legal regulations providing the foundations for the emergence of an infection control system did not come into existence until 2001. Therefore, in Poland, the system of surveillance of HAIs is relatively young, and since there is no tradition of HAI control and a deeply rooted uncertainty regarding this field, the situation is not conducive to continuous, active surveillance or even to registration of HAIs. It is also substantiated by Allerberger et al. [2] who wrote that, in Central and Eastern European countries, there is often insufficient information on the surveillance of HAIs as well as publicly available information on epidemiological methods and indicators. This is corroborated by Ider et al. [3] in their study of how infection control systems function in the countries of the post-Soviet bloc. They found weak commitment, lack of resources, poor
specialist knowledge and insufficient reporting or publishing of information on HAI epidemiology. Additionally, the countries of Central and Eastern Europe exhibit enormous differences with regard to legislation, structural elements and indicators of the methods for infection control and prevention [2]. Also, according to a report on HAIs by WHO (for 1995–2010), in low- and middle-income countries, regular HAI surveillance can prove difficult. In the report, our region, i.e. Central and Eastern Europe, is represented only by Lithuania and Latvia, as well as Serbia (which is not part of the EU) [4]. In Poland, there are no clear or straightforward rules of conduct in surveillance and there is no obligation to provide information on infections to the public, hence, the data concerning Polish hospitals are extremely scarce, which may be a confirmation of the thesis put forward by the authors of the WHO report on difficulties in implementing HAI surveillance, especially active and targeted surveillance.

Zingg et al. have identified ten key elements essential for effective HAI control in the day-to-day practice of every hospital. They are, among others, organization of infection control structures at the hospital level; staff: nurses’ workload and forms of employment; correct application of guidelines; education and practice; multimodal and multidisciplinary prevention programmes, positive organizational culture and audit and feedback [5]. Hence, a meaningful impulse for the adoption of activities associated with infection control can arise in the form of the hospital’s efforts to carry out accreditation, done by an external entity. In Poland, accreditation and the entire process of preparation for it, consisting in the implementation of standards of service quality and safety of care, is voluntary and free of charge and carried out by the Quality Monitoring Centre in healthcare, a unit of the Ministry of Health.
The objective of this study was to analyse the impact of infection control and prevention activities in patients with locomotive organ diseases treated surgically and the implementation of “perioperative control card (perioperative checklist)” which was part of the hospital’s preparation for accreditation. The authors and the Infection Control Team of the investigated hospital, in their previous analysis of research material from 2009–2013 [6], indicated a problem of high, higher than expected, SSI incidence rate in surgical patients and the urgent need for action concerning the prevention and control of SSIs. In 2014, the hospital was preparing, for the first time, to undergo the process of accreditation and the Infection Control Team decided to, at the same time, implement a series of interventions that should significantly improve patient safety; hence, the analysed material was divided into two time periods: years 2009–2013 (before accreditation) and years 2014–2018 (after accreditation).

MATERIAL AND METHODS

The investigated trauma and orthopaedics ward has 40 beds and is located in southern Poland. The hospital has its own microbiological laboratory. In the hospital, since 2001, there has been an active Infection Control Team which consists of a doctor, who is employed on 1/3 full-time equivalent basis, and 4 full-time nurse epidemiologists. Active surveillance of surgical site infections was introduced in the examined department in 2008.

In compliance with The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) and with the methodology of the National Healthcare Safety Network (NHSN), the operations performed have been divided into: hip arthroplasties (HPRO), knee arthroplasties (KPRO), and other
musculoskeletal surgeries: open (FX) and closed (CR) reduction of fracture, knee
arthroscopy (KART) and removal of fixation device (UZ) (Table 1). Patients are
admitted both electively and emergently. In the study period, emergencies
constituted 42.8% of CRs, 30.1% of FXs, 8.0% of UZs, 3.9% of ARTKs, 2.9% of
HPROs, 1.3% of KPROs, and 2.3% of others. A single dose of cephazolin was applied
in preoperative antibiotic prophylaxis at a dose of 1 or 2 g i.v. (according to body
mass) in the operating room. For HPRO and KPRO, prophylaxis with cephazolin was
continued every 8 hours for 24 hours.

| Code  | Operative procedures: ICD-9                                                                 |
|-------|---------------------------------------------------------------------------------------------|
| HPRO  | Hip Prosthesis (HPRO): 00.70–00.73; 00.85–00.87; 81.51–81.53.                               |
| KPRO  | Knee Prosthesis (KPRO): 00.80–00.84; 81.54; 81.55.                                           |
| FX    | Open Reduction of Fracture (FX): 79.21; 79.22; 79.25; 79.26; 79.31; 79.32; 79.35; 79.36; 79.51;
       | 79.52; 79.55; 79.56.                                                                         |
| CR    | Closed Reduction of Fracture with Internal Fixation (CR): 79.11–79.18; 79.191–79.194       |
| UZ    | Removal of Fixation Device (UZ): 78.6                                                      |
| KART  | Knee Arthroscopy (KART): 80.26                                                             |
| OTHER | Orthopaedic surgery other than HPRO, KPRO, FX, CR, ZU, KART                                 |

The hospital in which the research was carried out participates in a voluntary
nationwide system of active registration of hospital infections, in accordance with
the methodology of the Healthcare-Associated Infections Surveillance Network (HAI-
Net), European Centre for Disease Prevention and Control (ECDC) [7]. In 2008–2012,
infections were detected, qualified and registered according to the definitions by
the National Healthcare Safety Network (NHSN) [8], which are in line with the ECDC
definitions [7, 9]. The SSIs were qualified as superficial / deep incisional or
organ/space. The follow-up period was 30 days for the superficial SSIs, and 90 days
for deep or organ/space infections following arthroplasties. Due to the
predominance of deep incisional SSIs (SSI-D), the authors have decided that only
this group will undergo detailed analysis. The postoperative follow-up visits take
place 6 weeks after HPRO and KPRO, in other cases: 2 or 3 days after discharge.

The results of the observation were divided into two time periods: years 2009–2013 (first period) and years 2014–2018 (second period). In 2013, works have commenced to prepare the hospital and the examined department for the process of accreditation. In the framework of this development, in 2014, a perioperative checklist was introduced in the ward under investigation, which inspected the execution of procedures, including the newly-implemented practices, among others:

1. bathing the patient prior to surgery with antiseptic soap,
2. changing bed linen and the patient’s underwear immediately before surgery,
3. operative field hair removal immediately before surgery using surgical clippers – without the use of blades,
4. surgical hand hygiene according to the WHO recommendations,
5. disposable surgical draping,
6. the application of antiseptic to the edges of the wound before stitching the skin,
7. giving systematic (every 6 months) feedback concerning infections to the department.

The ward was granted a positive Accreditation Certificate in 2014, thus, this year became the basis for the comparison of the results from the period before and after accreditation.

To compare both periods, the choice was made to examine the SSI incidence rate and analyse variables, such as: waiting time for surgery in the ward, duration of stay in the ward, number of days from surgery to SSI detection, the number of SSIs detected after discharge. Additionally, demographics of surgical patients, their age and genders were also provided. Incidence rate was calculated as the number of SSI cases per 100 operations.

Statistical analysis of the collected material employed the IBM SPSS (SPSS –
Statistical Package for the Social Sciences) STATISTICS 24 (Armonk, NY, USA) and Microsoft Excel (Microsoft Office 2016, Redmond, WA, USA) software. Statistical analysis was carried out with the use of basic statistical parameters, i.e. mean, 95% confidence intervals for the mean, median, and standard deviation. The risk of developing SSI-D in particular types of surgeries was compared for the two analysed periods by calculating the odds ratio (OR). In order to compare the frequency of occurrence of the variants of the qualitative trait, Pearson’s chi-square test of independence was used, Fisher’s exact test was employed for variables of small numbers and the ANOVA test for quantitative variables. The level of significance was p < 0.05.

Our experiences from the previous years have already been partly discussed, but those discussions concerned different types of infections and patient populations [6].

RESULTS

The overall number of subjects included in the study, during the entire 10-year period, amounted to 15,678 surgical patients. In total, 272 different HAIs were detected in various types of procedures, of which 168 (62%) were SSIs, including 163 SSI-D, i.e. 98% of all SSIs. HAI incidence rate amounted to 1.7% per 100 hospitalizations, SSI incidence was 1.1% (SSI-D 1%). The first symptoms of SSI-D were generally observed 37 days after surgery (95% CI 29.8–44.9), and the majority of SSI-D cases, i.e. 104 people (64.2%), required rehospitalisation – the diagnosis was made after the patient was discharged from hospital. In the analysis of differences between the two periods studied, no statistical differences were found in SSI-D incidence in HPRO (p = 0.74), KPRO (0.07) and in KART and UZ procedures. A
significantly lower incidence was found after fracture reductions: FX and CR, SSI-D incidence were respectively 21% vs. 0.7% (OR 3.1 95%CI 1.4–6.6, p < 0.01) and 2.1 vs. 0.8% (OR 2.4 95%CI 1.0–5.9, p < 0.05). Among the other elements under investigation, the patient age changed significantly: in HPRO, it increased from the initial 67 years to 70 years and, in KART, it decreased from 35 years to 33 years. There was a significant increase concerning the proportion of men in HPRO, from 35.3–41.9%, and in KART, from 61.9–69.8%. The organization of work in the ward expressed in waiting time for surgical procedures and duration of hospitalization have changed significantly, especially for HPRO, but the extent of changes was small, max by 1 day (Table 2).

Table 2

| Operation type | endoprosthesis | fracture reduction | Knee arthroscopy, removal of fixation device and others |
|----------------|----------------|--------------------|-----------------------------------------------------|
|                | HPRO           | KPRO               | FX        | CR        | KART     | UZ       |
| Year           | 2009–2013      | 2009–2013          | 2009–2013 | 2009–2013 | 2009–2013 | 2009–2013 |
| Number of surgeries |
| 1491          | 122           | 347               | 500       | 1303      | 898      | 724       | 669      | 655      | 588     |
| Number of SSI-D |
| 16            | 16            | 4                 | 9         | 27        | 10       | 19        | 6        | 6        | 3       | 5       | 5       |
| Incidence rate (%) |
| 1.1           | 1.3           | 1.2               | 1.8       | 2.1       | 0.7      | 2.1       | 0.8      | 0.9      | 0.4     | 0.8     | 0.9     |
| Fisher's test | p = 0.740; 0.9 (0.4–1.8) | p = 0.068; 0.6 (2.1) | p < 0.01; 6.6 | 3.1       | 1.4      | p < 0.05; 1.0–5.9 | 2.4      | p = 0.232; 2.1 (0.5–8.4) | p = 0.530; 0.9 (0.3–3.2) |
| Waiting time for operation in the ward [days] | 3 (2); 4.1 | 3 (2); 4.5 | 5 (2); 2.6 | 3 (2); 3.7 | 3 (2); 4.1 | 3 (2); 4.3 | 2 (1); 3.6 | 2 (1); 2.8 | 2 (1); 2.0 | 1 (1); 1.2 | 2 (1); 5.1 | 2 (1); 3.9 |
|--------------------------------------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| ANOVA (p) | p = 0.049 | p = 0.383 | p = 0.641 | p = 0.048 | p < 0.05 | p = 0.117 |
| Duration of stay in the ward [days] | 13 (11); 6.6 | 12 (10); 7.5 | 13 (10); 8.2 | 10 (8); 8.6 | 8 (6); 7.3 | 8 (7); 6.8 | 6 (5); 5.2 | 4 (3); 3.4 | 4 (3); 2.4 | 3 (2); 9.0 | 3 (2); 4.9 |
| ANOVA (p) | p = 0.047 | p = 0.543 | p < 0.001 | p < 0.001 | p = 0.186 | p < 0.001 |
| Number of days from surgery to SSI detection | 47 (45); 36.1 | 43 (30); 23.9 | 25 (15); 14.4 | 41 (17); 27.9 | 50 (29); 34.6 | 61 (44); 57.4 | 34 (24); 20.1 | 26 (11); 13.6 | 24 (24); 5.5 | 9 (3); 14.3 | 11 (4); 17.0 |
| SSI-D: diagnosis mode [n] | p = 0.840 | p = 0.627 | p = 0.617 | p = 0.293 | p = 0.919 | p = 0.876 |
| Fisher's test; OR (95%CI) | p = 0.238; 0.5 (0.11–1.92) | p = 0.636; 0.4 (0.03–5.71) | p = 0.066; 6.9 (0.75–62.96) | p = 0.070; 0.1 (0.01–1.03) | p = 0.417; n/a | p = 0.50; 2.3 (0.18–28.26) |
| Patient age [years] | 67 (67); 12.3 | 70 (71); 11.8 | 69 (71); 8.8 | 69 (70); 8.1 | 60 (61); 21.7 | 61 (63); 21.5 | 54 (58); 22.1 | 55 (59); 21.2 | 35 (34); 13.0 | 33 (31); 12.9 | 46 (44); 22.3 | 44 (43); 18.8 |
| ANOVA (p) | p < 0.001 | p = 0.538 | p = 0.212 | p = 0.507 | p < 0.01 | p = 0.183 |
| Gender | | | | | | | | | | | | |
| Female | 975 (64.7) | 772 (71.2) | 374 (74.8) | 49 (56.3) | 752 (55.1) | 435 (47.4) | 325 (44.4) | 245 (38.1) | 203 (30.2) | 223 (37.9) | 223 (37.9) |
| Male | 532 (35.3) | 519 (28.8) | 1265 (84.7) | 581 (43.7) | 614 (44.9) | 482 (52.6) | 405 (55.6) | 398 (61.9) | 469 (69.4) | 365 (62.1) | 223 (37.9) |
Among the SSI-D observed, 10.4% of the cases were not microbiologically diagnosed, and the remaining cases were dominated by Gram-positive cocci, specially Staphylococcus aureus, 74 (45.7%), and coagulase-negative staphylococci; rods of the family Enterobacteriaceae accounted for 14.1% and Gram-negative non-fermenting rods for 8.5% (Table 3).

**Table 3**
Most frequently isolated aetiological factors of SSI-D's in 2009–2018

| Pathogen                        | Total n(%) |
|---------------------------------|------------|
| Staphylococcus aureus           | 74 (45.4)  |
| Coagulase-negative staphylococci| 23 (14.1)  |
| Enterococcus faecium            | 7 (4.3)    |
| Enterococcus faecalis           | 1 (2.5)    |
| Streptococcus spp.              | 1 (0.6)    |
| Escherichia coli                | 7 (4.3)    |
| Enterobacter cloacae            | 6 (3.7)    |
| Klebsiella pneumoniae           | 1 (0.6)    |
| Citrobacter freundii            | 8 (4.9)    |
| Proteus mirabilis               | 1 (0.6)    |
| Pseudomonas aeruginosa          | 1 (0.6)    |
| Serratia spp.                   | 1 (0.6)    |
| Not detected / not collected    | 17 (10.4)  |
| Total                           | 163 (100)  |

**DISCUSSION**

The results obtained in this study were divided into two time periods: years 2009–2013 (first period – before accreditation) and years 2014–2018 (second period – after accreditation). Unfortunately, the actions implemented – multimodal strategy – turned out not to be fully effective since a significant reduction regarding incidence was obtained in only one category of treatments, i.e. both open and closed
reductions of fractures, where the incidence was significantly decreased by 3 and 2.5 times. It is a very significant accomplishment for the investigated department, as these were the surgeries that were most often performed. In the previous analyses by Wałaszek et al. [6], in 2008–2012, in the same department, FX incidence was 2.6–4.1%. In the literature, there are no other reports on the scale of this phenomenon in Polish trauma and orthopaedics wards. Furthermore, there are no reports from Europe on the incidence rate concerning infections associated with FX. In American NHSN research of 2006–2008 [10], the average SSI incidence associated with FX ranged from 1.1–3.4% depending on the presence of SSI risk factors, such as: duration of operation, ASA score, the degree of cleanliness of the operative field. A similar observation concerns CR procedures, for which in the studied department in 2008–2012, SSI incidence was 1.2–4.8% [6]. The nature of the procedure – no exposure of open tissues to external factors – and the fact that these procedures involved closed fractures, in which stabilization was introduced percutaneously, may indicate a close relationship between the occurrence of these infections and the moment of their implementation. It seems that the very labelling of these infections as a separate population in targeted surveillance directed the attention of the investigated department to the problem of SSI and resulted in reducing the number of SSIs. In the literature, data concerning the problem of SSI in such surgeries has not been touched upon.

On the other hand, the observed total incidence of 1% is a significantly good result considering previous Polish reports concerning SSI in orthopaedic surgery, e.g. in Sosnowiec, the SSI incidence was 6.6% [11], and, in Kraków, 2.6% [12]. However, multicentre data are needed to give a more complete picture of the situation and allow to draw comparisons, because, in view of the fact that data on SSI
epidemiology in Polish trauma and orthopaedics wards are absent and that there are such considerable discrepancies regarding the epidemiological results, rational inference is limited. Therefore, it is recommended to implement a broad and unified programme of surveillance of HAIs, including SSIs, which would involve a large number of entities, also in Poland.

A research on European Union countries conducted by the ECDC in 2008–2009 confirms the differences in incidence rate after HPRO and KPRO procedures between various countries; e.g. for HPRO, the lowest was recorded for Great Britain and Lithuania 0.3–0.4%, while the highest for Norway and Malta, from 2.8–3.8% [13].

The discrepancies are probably associated with the sensitivity of the method, as the presumed high SSI detection in Norway, but also with the organization of work and the whole system of health care organization as well as the flow of information between different participants of the surveillance systems, which is connected with infection detection in post-discharge care. At the same time, the risk of exposure to SSI following HPRO and KPRO observed in the examined ward for several years reflects the expected level of risk, i.e. it is comparable to the average obtained in the European HAI-Net programme. Also, the microbial aetiology does not differ from the reports of other authors [14].

Unfortunately, the data presented are not so optimistic. Our attention is drawn to the dominance of one of the forms of SSI, that is, the lack of superficial infections, despite the fact that they should make up - in the case of HPRO and KPRO - around 50–60% of cases [14]. At this point, two hypotheses can be made, one suggesting SSI-D overdetection, that is, the tendency to incorrectly classify cases, the other indicating too low detection of superficial SSIs. Therefore, it is very likely that the real SSI incidence is even 2 times higher. The investigated hospital does not
conduct any procedures with respect to process validation regularly, either in terms of the correctness of procedure performance or as regards the correctness of infection classification. In the authors’ opinion, it is the most important element concerning infection control that currently requires implementation in the study hospital.

An interesting observation, made possible by this analysis, can be done as regards patient demographics. A review of European data indicates that Polish patients are significantly younger (67 years and older) than the average patient population operated for HPRO and KPRO in Europe: median of 72 years. Also other Polish reports confirm this observation. In studies conducted in two Polish orthopaedic centres in 2005, the median ages were 68 and 67 years [15]. These results may suggest that inhabitants of other European countries enjoy better health than people in Poland, who require surgical intervention 5 years earlier, on average. This fact is even more disturbing when data from OECD from 2017 is taken into consideration, since the average waiting time for HPRO in Poland was 405 days, while, for example in the Netherlands, it is 42 days [16].

This retrospective study had some limitations. Firstly, the research involves only one centre. Secondly, in the period studied, despite participation in the multicenter programme, the surveillance of infection method was not validated, hence, its sensitivity is not known in this particular case.

Conclusion

The introduction of multimodal and multidisciplinary SSI prevention and epidemiology programmes in 2014 has resulted in lower SSI incidence rates in some types of orthopaedic operations. This trend was most strongly visible following FX
and CR fracture reductions. After HPRO, KPRO and other procedures, a stable, expected level of SSI incidence was maintained. The results described confirm the possibility of implementing an infection surveillance system also throughout Poland. Making this system stronger and encouraging its participants to make the results public can reinforce the regional and national surveillance systems. Especially combining the tasks of an infection control team with preparation for accreditation allows effective implementation of infection control practices. Such an approach, encompassing structural elements and indicators of infection prevention and control, integrating multimodal and multidisciplinary solutions, make it possible to strengthen the organizational culture resulting in the reduction of SSI risk. Problems associated with improving the hospital infection surveillance systems probably affect many other Polish trauma and orthopaedics wards, hence such active SSI surveillance should be adopted by other hospitals in Poland.

Declarations

Ethics approval and consent to participate

The use of data was approved by the Bioethical Committee of the Jagiellonian University (No. KBET /122.6120.118.2016 from 25.05.2016). All the data entered into the electronic database and analysed in this study was previously anonymised.

Consent for publication

Not applicable

Availability of data and materials

The datasets generated or analysed during this study are available and can be accessed from Anna Rozanska (e-mail: a.rozanska@uj.edu.pl) on reasonable inquiry.
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