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Research Article

Single Institution's Postoperative Infections: A Prospective Descriptive Study on Incidence, Risk Factors, Management and Outcome

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Abstract

Background: Evaluate the incidence, potential risk factors, management and outcome of postoperative infections.

Methods: This is a prospective study between August 2017 and October 2018 taking place in a Middle Eastern tertiary care center. The sample was collected using infectious disease consultations, and cases specified by doctors and residents of surgery. The definition of the surgical site infection used was the one defined by the Center for Disease Control and Prevention (CDC). The following variables were collected: age, arterial hypertension, diabetes, hyperlipidemia, tobacco smoking, immunosuppression, type of surgery, preoperative antibiotic therapy, the site of infection, the causative organism, the resistance profile of the infective organism, the treatment and the prognosis of the infection.

Results: *Escherichia coli* (36%) was the most frequent causative bacteria in postoperative infections, followed by *Staphylococcus aureus* (10%). 65% of the Enterobacteriaceae secrete an extended spectrum beta lactamase (ESBL), and 12.5% of the *Staphylococcus aureus* were methicillin resistant. The Altemeier score seems to affect the incidence of infections. The antibiotic prophylaxis was well targeted in 90.9%. A targeted postoperative antibacterial treatment was initiated in 86% versus 14% of inappropriate antibiotics. The duration of treatment was appropriate in 72.8% of cases. These postoperative infections had a favorable evolution in 58%, and a recurrence rate of 23%. No potential risk factor was found significant in this study.

Conclusion: Strategies to prevent and decrease such complications must be implemented in every hospital. More studies are needed to determine the frequency and epidemiology of the postoperative infections. Better-targeted management is warranted.

Keywords: Postoperative Infections; Surgical Site Infections; Antibiotic Therapy; Antibiotic Prophylaxis; and Outcome

Background

Postoperative infections are one of the major causes of morbidity and mortality [1]. No global incidence of such complications has been published. The lack of such studies is probably due to the high variability of their frequency, depending on the type of surgery, on local factors (expertise of the surgeon, hospital facilities) and on the patient's risk factors. The percentage of postoperative infection has been estimated to be around 9 to 30% in the United

States using the National Nosocomial Infections Surveillance System [2]. Postoperative infections not only increase the length of hospitalization but also the cost of care [3].

The Centre for Disease Control and Prevention (CDC) defined surgical site infections (SSIs) as infections of the incision or organ or space that occur after surgery [4]. The CDC categorized the SSIs into three groups depending on the depth of the infection: infection of the superficial wound occurring in the skin and subcutaneous tissue, infection of the deeper incision reaching the tissues, and infection of organ or the space between the viscera [5]. Almost half of these healthcare associated infections are preventable when evidence-based strategies are applied [6]. Preventive measures fall into three groups: the preoperative, per operative and postoperative measures [4].

This prospective study was designed to assess the rate of these infections, the causative agents, risk factors and management of such complications. The aim is to improve the prevention and management of postoperative infections.

Materials and Methods

This is a prospective study between August 2017 and October 2018 taking place in a Middle Eastern tertiary care center. Patients meeting the inclusion criteria (see below) were followed. The sample was collected using infectious disease consultations, and cases specified by doctors and residents of surgery. The definition of the surgical site infection used was the one defined by the Center for Disease Control and Prevention (CDC) [7]. The information was collected from computerized records and patients were followed prospectively after meeting the inclusion criteria. Authorization by the ethical committee was obtained for data processing and publication.

Inclusion criteria

- Surgeries performed between August 2017 and October 2018
- Surgeries taking place at the tertiary care center
- Patients being 15 years or older
- Patients having a postoperative infection within 30 days of the initial surgery.

Exclusion criteria

- Postoperative surgical infections appearing more than 30 days postoperatively
- Surgeries performed outside the tertiary care center
- Surgeries performed before August 2017 and after October 2018
- Patients aged less than 15 years old.

The following variables were collected using a standardized data collection form: age of the patient, arterial hypertension, diabetes, hyperlipidemia, tobacco smoking, immunosuppression, antibiotic prophylaxis, type of surgery (Altemeier score) [8], laparoscopic surgery, preoperative antibiotic therapy, the site of infection, the causative organism, the resistance profile of the infective organism, the antibacterial treatment (targeted antibiotic therapy, combination of antibiotics, duration), and the course of the infection (cure, relapse, reinfection with other germs, death).

The statistical analysis was done using SPSS software version 20 (Statistical Package for the Social Sciences). The one sample χ^2 test was used to analyze the likely impact of categorical variables and the incidence of post-operative infections. The unpaired T-test (or Student's T test) was used to find out if there is a significant difference between means of continuous variables. A p value of 0.05 or less was considered significant and confidence interval of 95% was selected for the analysis.

Results

6300 surgeries were done during the period of this study. Postoperative infections occurred in 62 patients, making the incidence 0.98%. The mean age of the sample studied was 56.56 years with a standard deviation of 17.11. (Chart 1 shows the age distribution) The average operating time was 321.67 minutes with a standard deviation of 171.34 (minimum value of 60 minutes and maximum value of 660 minutes). The use of antibiotic therapy in the previous 6 months preceding the operation was noted in 15 patients (24% of the studied population): two patients received the antibiotic targeting a different site of the operation whereas the rest had an antibiotic treating the operated site. In 90.9%, the preoperative antibiotic prophylaxis administered 30 minutes before the surgery was well adapted. Cephalosporins were the most used preoperative antibiotic followed by penicillin and aminoglycoside (Details in chart 2). 70% of patients had a urinary catheter during their operation.

The skin and soft tissue infections accounted for 80% of postoperative infections, followed by the urinary tract infections 8.2%, followed by Clostridium Difficile infections in 7.6%, and pneumonia in 4.2% of cases.

Urologic operations were the most frequently complicated surgeries (34.4% of the total postoperative infections), followed by general surgery procedures (19.7%). Detailed numbers of postoperative infections by type of operation are shown in table 1.

Of the SSIs, superficial skin infections occurred in 50% of cases, urologic tract infections in 28.3%, abdominal infections in 10.9%, post-operative meningitis in 6.5%, and prosthetic infections in 4.3%.

The most frequent organisms causing the infections (postoperative and surgical site infections) were *Escherichia coli* (36%), followed by the *Staphylococcus aureus* (10%) and Pseudomonas aeruginosa (7.2%). No bacterial growth after 5 days of culture was obtained in 14.4%. No cultures were drawn in 2% of cases. Detailed percentages of causative bacteria are presented in table 2. The antibacterial resistance profile of the isolates was as follows:

- 65% of gram-negative Enterobacteriaceae secreted an extended spectrum beta-lactamase
- 44.8% of gram-negative Enterobacteriaceae were resistant to quinolones
- 3.6% were Enterobacteriaceae were resistant to carbapenem
- 12.5% of *Staphylococcus aureus* was resistant to methicillin.

Potential risk factors for postoperative infection have been studied:

- Older age was not associated with significant postoperative infection risk (p value = 0.819).
- The increased duration of operation was not significantly associated with postoperative infection risk (p-value= 0.382).
- Arterial hypertension, hyperlipidemia, diabetes, immunosuppression, tobacco smoking, cardiac failure, and coelioscopic surgery were not significantly associated with postoperative infection risk (details in table 3).
- The use of antibiotic therapy in the last 6 months preceding the surgery, targeting or not the operated site, does not seem to influence the incidence of post operative infections (p value > 0.05) (Table 3).
- Altemeier 1 score appears to be a protective factor for postoperative infections (p-value = 0.024 with an Odd Radio <1). The scores 2, 3, and 4 have a value of p-value> 0.05, which do not seem to affect the post-operative infections (details in table 4).

The postoperative antibiotic treatment is analyzed to see the rate of targeted antibiotic therapy, the inappropriate antibiotic use, and the duration of treatment (details in table 5). The most frequently used antibiotics were carbapenems (29.8%), glycopeptides (23.1%) and piperacillin/tazobactam (11.5%).

58% of patients had a favorable outcome at the end of the antibiotic cure and a complete resolution of the infection. 23% of patients had a recurrence of their infection. No death due to a postoperative infection occurred in the studied population.

Chart 1: Age distribution of the studies population.

Chart 2: Antibiotic prophylaxis administered 30 minutes before the operation of the 62 postoperative infected patients.

Type of operation	Postoperative infections No. (%)
Urologic	21 (33.8)
General Surgery	12 (19.3)
Orthopedic	7 (11.3)
Neurologic	7 (11.3)
Gynecologic	6 (9.6)
Cardiac	4 (6.4)
Plastic and reconstructive	3 (4.8)
Head and neck	2 (3.3)

Table 1: Number of postoperative infections by type of operation.

Bacteria	Total postoperative infections[1] No. of cultures (%)	SSIs[2] No. of cultures (%)
Escherichia coli	29 (36)	20 (40.8)
Staphylococcus aureus	8 (10)	7 (14.3)
Pseudomonas aeruginosa	6 (7.2)	6 (12.3)
Enterococcus spp.	5 (6)	4 (8.2)
Anaerobes	5 (6)	4 (8.2)
Other gram positives[3]	1 (1.2)	1 (2)
Other gram negatives[4]	10 (12)	7 (14.2)
Clostridium difficile	5 (6)	None
No bacterial growth	11 (14)	None
Total number of cultures	80 (98.4)[1,5]	49 (100)

Table 2: Percentage of causative bacteria in total postoperative infections and SSIs.

- No culture was drawn in 2% of cases
- SSIs: Surgical site infections
- Other gram positives consisted of staphylococcus coagulase negative and streptococcus group C
- Other gram negatives consisted of *Klebsiella pneumoniae*, *Klebsiella oxytoca*, and *Acinetobacter baumannii.*
- Nine patients had multiple sites of infection with more than one positive culture.

	No. of patients (%)	p-value	Value of Odd Ratio	Confidence interval 95%	
				Lower	Upper
Arterial hypertension	28 (46)	0.375	1.625	0.554	4.771
Hyperlipidemia	19 (31)	0.753	1.204	0.379	3.821
Diabetes	8 (13)	0.844	0.857	0.184	3.999
Immunosuppression[1]	2 (3)	0.115	0.905	0.788	1.039
Cardiac failure	16 (26)	0.356	1.821	0.505	6.564
Tobacco smoking	28 (46)	0.845	0.900	0.312	2.595
Coelioscopic surgery	2 (3)	0.297	1.053	0.980	1.130
Previous antibiotic treatment targeting the operated site[2]	13 (22.4%)	0.484	1.667	0.395	7.041
Previous antibiotic treatment not targeting the operated site[2]	2 (3.4%)	0.329	1.057	0.979	1.142

Table 3: $\chi 2$ test studying several variables as potential risk factors for postoperative infections in the studied population

- Immunosuppression included corticosteroid, immunosuppressive therapy, chemotherapy and congenital immunodeficiency.
- During the 6 months preceding the operation.

	Count	p-value	Odd Ratio	Confidence interval 95%	
				Lower	Upper
Altemeier 1	11 (18%)	0.024	0.22	0.05	0.87
Altemeier 2	22 (36.1%)	0.172	0.47	0.15	1.40
Altemeier 3	8 (13.1%)	0.161	4.24	0.48	37.06
Altemeier 4	18 (29.5%)	0.059	3.60	0.90	14.30

Table 4: $\chi 2$ test studying the likely impact of Altemeier's score on the incidence of post-operative infections.

	Number of patients	Total number of patients	Percentage
Targeted antibiotic therapy	49	57	86%
Inappropriate antibiotic therapy	8	57	14%
Well adapted duration of antibiotic therapy	43	59	72.88%

Table 5: Characteristics of antibiotic treatment for postoperative infections.

Discussion

This study shows that the most frequent organism associated with postoperative infections was *Escherichia coli* (36%), followed by *Staphylococcus aureus* (10%), *Pseudomonas aeruginosa* (7.2%), and *Enterococcus* spp. (6%). In contrast, according to record of the National Nosocomial Infections Surveillance in the US published in 1996, the most frequently encountered postoperative bacteria (more specifically SSIs) was *Staphylococcus aureus* [9]. This difference may be explained by the fact that most postoperative infections seen in our study were post urologic or general surgery procedures. An article published in January 2017 about the most frequently encountered bacteria post urologic interventions showed that *Enterococcus* spp. (27.1%) was the most frequent, followed by *Escherichia coli* (22.9%) [10]. *E. coli* was the most frequently isolated bacteria in general surgery according to a recent study [11]. A study analyzing the incidence of SSIs per site of surgery should be conducted.

Urinary infections outside of SSIs accounted for 18% of postoperative infections. They might be related to the presence of urinary catheter for a prolonged period. In the United States, the incidence of catheter associated urinary tract infection in 2012 was 1.4 to 1.7 per 1,000 catheter days in inpatient adult and pediatric medical/surgical floors [12], hence the importance of removing catheters when no longer necessary.

This study showed the resistance profile of Enterobacteriaceae and *Staphylococcus aureus*: 65% ESBL producing GNB, 44.8% of resistance to quinolones, 3.6% of carbapenem-resistant Enterobacteriaceae and 12.5% of methicillin resistant *Staphylococcus aureus* (MRSA). Compared to other studies [10], these percentages indicate a higher resistance of GNB in the studied population. An effort needs to be done to prevent such resistant infections.

Regarding the operating time, the average in this study was 321.67 minutes +/- 171.34. We did not find a significant correlation between the operating duration and the incidence of postoperative infections. A study published in August 2017 found an increase of 13%, 17%, and 37% of the postoperative infectious risk every 15 minutes, 30 minutes, and 60 minutes respectively [13].

Diabetes did not affect the incidence of postoperative infection in this study. A systematic review and meta-analysis on diabetes and its risk for postoperative SSIs, showed that it is an independent risk factor for SSIs [14].

Tobacco smoking did not affect the incidence of postoperative infection in this study. According to a study published in 2017, tobacco is an essential risk factor for postoperative infections: the risk doubles if the patient smokes on the day of the surgery and reduced in case of cessation on the day of the operation [15]. Tobacco smoking delays healing of the wound, and promotes postoperative complications such as hematomas, thus causing an increase in postoperative infections [16].

Altemeier score reflects the state of the wound: clean or contaminated wound. Altemeier score 1 appeared to be a protective factor for postoperative infections in this study. However, no potential link between Altemeier scores 2, 3 and 4 and the incidence of postoperative infections was found. A contaminated wound is associated with a higher risk of postoperative infection: 2% of SSIs is reported in the presence of a clean wound, and > 30% in the case of a dirty wound [17].

Preoperative antibiotic prophylaxis was inappropriate in 9% of cases. This can be corrected by implementing protocols in the hospital for antibiotic prophylaxis use for the most frequently encountered surgical conditions.

This study has several limitations: it should be noted that the risk factors studied were based on the population having contracted an infection postoperatively only. Comparing to the population that did not have a postoperative infection would have been more reliable. The sample chosen in this study may not represent the real population: the sample was chosen by referring to the infectious diseases consultations, and some cases specified by residents and surgeons. In addition, some information bias may be present: missing or unwritten information by residents in the electronic records. Data collection was pretty difficult as there was no unified track to follow and plenty of missing notes in the surgical files that obliged us to seek the missed information by direct contact with the surgeons, residents and patients opposed to other international hospitals with surveillance methodology of surgical procedures and quality of follow-up [18].

Conclusion

This is a descriptive study that reflects the importance of postoperative infections. This topic remains a major cause of increased length of hospitalization and cost of care. Strategies to prevent and decrease such complications must be implemented in every hospital. More studies are needed to determine the frequency and epidemiology of the postoperative infections.

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