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ORIGINAL PAPER

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Examination of Risk Factors for the Development of Surgical Site Infections

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ABSTRACT

Introduction. Hospital-acquired infections (HAI) and surgical site infections (SSI) are a global public health problem. The aim of the study was to determine the incidence of SSIs at the Surgical Clinics of the University Clinical Centre Banja Luka and to identify risk factors for the development of SSIs. **Methods.** In order to determine the frequency of SSIs through the incidence compared to the patients operated at the Surgical Clinics of the University Clinical Centre Banja Luka, we conducted a prospective cohort study which encompassed 11,216 operated patients, in the period from November 11th, 2014 to September 30th, 2015. In order to identify risk factors for the development of SSIs, a nested case-control study of risk factors for SSIs was conducted. The study group consisted of patients who were diagnosed with SSIs in the period of monitoring, while the control group was consisted of patients without SSIs who corresponded with the study group in age and sex. **Results.** The highest values of incidence of SSIs were observed at the Department of Anesthesia and Intensive Care (2.65%), Department of Orthopaedic Surgery (2.48%) and the Department of Vascular Surgery (2.15%), and the lowest ones at the Department of Urology (0.59%). Among the cases of SSIs, deep infections of the surgical site were the most represented (82.7%). Multivariate logistic regression was used to identify the following independent risk factors: length of post-operative stay in hospital ($p=0.000$; OR=1.062; 95% CI=1.037-1.087), re-intervention ($p=0.000$; OR=22.409; 95% CI=6.361-79.071) and corticosteroids ($p=0.023$; OR=4.141; 95% CI=1.221-14.047). **Conclusion.** The incidence of SSIs at the Surgical Clinics of the University Clinical Centre Banja Luka is at the level of hospitals in developed countries. There are a number of risk factors for SSIs, which may be prevented.

Keywords: surgical site infections, incidence, risk factors.

1. INTRODUCTION

A hospital-acquired infection (HAI), also known as a nosocomial infection, is an infection which occurs in patients and staff at the hospital or other health care facility. These infections may be manifested in pupils and students in training. Infections will be considered to be acquired at hospital if they become evident 48 hours after the admission or later. Surgical site infections (SSIs) occur within 30 days after the surgical intervention, if an implant has not been positioned, or up to one year if it has (1).

In addition to urinary tract infections, pneumonia and blood infections, surgical site infections (SSIs) represent one of the most common localizations of hospital-acquired infections. It is estimated that, in the USA, approximately 157,000 patients a year acquire the SSIs (2) and that these infections cause additional costs of 3.3 billion dollars (3). According to the results from the study conducted by Haley and associates, one third of a total number of intra-hospital infections may be prevented thanks to the epidemiological surveillance (4, 5).

Based on the findings by Worth and associates, who conducted a prospective cohort study, which included 183,625 procedures in the period from 2002 to 2013, there has been a significance reduction in the incidence rates of SSIs due to the epidemiological surveillance. During that period, 5123 cases of SSIs were registered. It was noted that the annual risk for development surface SSIs was reduced by 11% (RR, 0.89; 95% confidence interval CI, 0.88-0.90), 9% for deep SSIs (RR, 0.91; 95% CI, 0.90-0.93), 5% for organ/space infections (RR, 0.95; 95% CI, 0.93-0.97) (6).

With the purpose of effective prevention of SSIs, it is necessary to know the risk factors associated with surgery.

2. AIM OF THE STUDY

- to identify the incidence rate of SSIs at the Surgical Clinics of the University Clinical Centre Banja Luka
- to identify risk factors for the development of SSIs.

3. PATIENTS AND METHODS

In order to determine the frequency of SSIs through the incidence compared to the patients operated at the Surgical Clinics of the University Clinical Centre Banja Luka (except for the Clinic of Pediatric Surgery and Maxillofacial Surgery Clinic), we conducted a prospective cohort study in the period from November 11th, 2014 to September 30th, 2015. The study included 11.216 operated patients. The incidence of SSIs in relation to the operated patients was established.

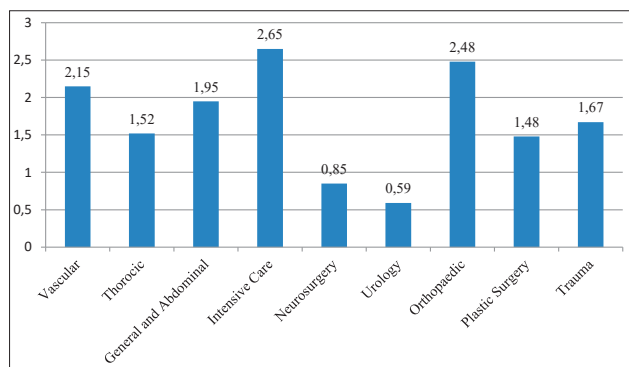
To identify risk factors for SSIs in the prospective cohort study, we conducted the nested case-control study of risk factors for SSIs. The study group consisted of patients who were diagnosed with SSI in the period of monitoring. For each patient with SSI, two controls were identified, that is, two chronologically subsequent patients of the same sex and similar age (± 5 years) who had undergone the surveillance, and who did not acquire the SSI.

SSIs were identified by a personal examination of the patient's condition, the existing medical records (medical history, temperature charts, laboratory, microbiological samples taken from the surgical site, etc.), use of definitions and protocol of the European Centre for Disease Prevention and Control (ECDC) (7). The study only included the patients who had signed a written consent to participate in the study.

Statistical analysis of data was conducted with the help of software package SPSS 20.0 for Windows. In this study, we used methods of descriptive and analytical statistics. Out of methods of analytical statistics, the following were used in the study: Student's *t* test, chi-squared (χ^2 test) and Fisher's exact test probability. The significance of the independent variables in the univariate and multivariate logistic model was estimated with the probability $p \leq 0.05$.

4. RESULTS

The incidence study included 11.216 operated patients. The highest values of incidence of SSIs were observed at the Department of Anesthesia and Intensive Care (2.65%), Department of Orthopaedic Surgery (2.48%) and the Department of



Graph 1. Incidence Rate of SSIs

Vascular Surgery (2.15%), and the lowest ones at the Department of Urology (0.59%) (Graph 1).

Among the cases of SSIs, the most represented were deep

Characteristics	Cases N = 173	Controls N = 344	p
Average age	63.53	63.41	0.929 \clubsuit
< 25 years	2 (1.16)	5 (1.45)	0.076**
25 – 44	19 (10.99)	32 (9.30)	0.545*
45 – 64	64 (37.00)	131 (38.00)	0.810*
65 – 79	67 (38.72)	140 (40.70)	0.666*
≥ 80	21 (12.13)	36 (10.46)	0.566*
Gender m/f	105/68	212/132	0.837 *
Neoplasma	57 (32.9)	103 (29.9)	0.485 *
Diabetes mellitus	24 (13.8)	52 (15.5)	0.706*
Chronic liver disease	0 (0)	5 (1.4)	0.174 **
Chronic pulmonary disease	3 (1.7)	10 (2.9)	0.558 **
Renal Insufficiency	4(2.3)	17 (4.9)	0.236 **
Infection at the admission	58 (33.5)	0 (0)	0.000**
Obesity	0 (0)	2 (0.6)	0.554**
Other intra-hospital infection	11 (6.3)	7 (2.0)	0.011*
Malnutrition	1 (0.5)	0 (0)	0.335**

Table 1. Characteristics of the respondents in the nested case-control study. * χ^2 test. ** Fisher's test. \clubsuit – *t* test

Risk factor	B*	SE	p	OR†	95% CI‡
Length of hospitalization in the department	0.082	0.011	0.000	1.086	1.062-1.109
Preoperative hair removal	0.648	0.250	0.009	1.913	1.172-3.122
Length of time from hair removal to operation	0.035	0.017	0.040	1.036	1.002-1.071
Length of operation	0.006	0.001	0.000	1.006	1.003-1.009
Number of people in the operating room	0.233	0.100	0.019	1.262	1.038-1.534
Level of contamination	0.417	0.147	0.005	1.517	1.137-2.025
ASA4	1.048	0.474	0.027	2.852	1.125-7.227
Stay in the Intensive Care Unit	1.356	0.339	0.000	3.879	1.996-7.540
Length of stay in the Intensive Care Unit	0.288	0.104	0.006	1.334	1.088-1.636
NNIS 0	-0.466	0.188	0.013	0.628	0.434-0.907
Stoma	1.127	0.403	0.005	3.085	1.399-6.803
Central vascular catheter	1.240	0.525	0.018	3.456	1.235-9.673
Length of drainage	0.153	0.027	0.000	1.165	1.105-1.229
Postoperative wound dehiscence	3.688	0.605	0.000	39.961	12.203-130.860
Length of urinary catheterisation	0.120	0.021	0.000	1.127	1.081-1.175

Tabela 2. Risk factors for the development of SSIs identified by univariate logistic regression. * -coefficient; † -odds ratio; ‡ -confidence interval

infections of the surgical site (82.7%) and organ /space infections (15%) which is shown in Table 1. Surface SSIs were represented at 2.3%. There were no differences in age ($p=0.929$) and gender ($p=0.837$) between the patients from the study and control group, as shown in Table 1. The respondents did not differ in the presence of comorbidities, such as diabetes, malignant diseases and obesity.

Risk factors for the development of SSIs, identified with the use of univariate logistic regression, are shown in Table 2. SSIs were more frequent in patients who had their hair removed preoperatively ($p=0.009$; $OR=1.913$; $95\% CI= 1.172-3.122$), patients with drainage ($p=0.000$; $OR=1.165$; $95\% CI=1.105-1.229$) and patients with stoma ($p=0.005$; $OR=3.085$; $95\% CI= 1.399-6.803$). NNIS0 was a protective factor for the development of SSIs ($OR=0.628$; $95\% CI= 0.434-0.907$). Multivariate logistic regression was used to identify three independent risk factors

associated with SSIs: length of stay ($p=0.000$; $OR=1.062$; 95% $CI=1.037-1.087$), re-intervention ($p=0.000$; $OR=22.409$; 95% $CI=6.361-79.071$) and the usage of corticosteroids ($p=0.023$; $OR=4.141$; 95% $CI=1.221-14.047$).

5. DISCUSSION

HAIs represent a global public health problem as they increase morbidity and mortality. Furthermore, they represent a significant economic cost and have a negative effect on patients' quality of life (8).

In our study, the cumulative incidence of SSIs ranged from 0.59% at the Urology Clinic to 2.65% at the Department of Intensive Care Medicine, which corresponds to the SSI rates in developed countries.

In the study conducted by Ridgeway and associates in 102 hospitals in England, a cumulative incidence among patients who had undergone total hip arthroplasty was 2.23%, and in patients with partial arthroplasty, it was 4.97% (9).

Similar values were observed in the three-and-a-half-year study of the operated patients in Virginia and France (10, 11).

In the retrospective cohort study, conducted by Amri and associates, out of total number of 1481 patients who had undergone the surgery of colorectal cancer, 6.1% had SSIs (12).

Relatively few studies talk about the role of gender on the formation of the SSIs. In the study conducted by Kim and associates, who monitored the rates of SSIs in cranioplastic operations, it was proven that females were more susceptible to surgical site infections ($OR = 5.98$; $p = 0.000$), hence SSIs were almost six times more often registered in female patients (13).

Male patients in our study group were more frequently represented (105/68), but those differences were not statistically significant ($p = 0.837$; $OR = 1.040$; 95% $CI = 0.715$ to 1.513).

According to some studies, the population ages 70 or above has a significantly higher risk of developing SSIs, as compared to the young and healthy people (14, 15). In our study, age was not statistically significant with respect to the emergence of SSIs ($p = 0.928$; $OR = 1.001$; 95% $CI = 0.988$ to 1.014).

Most authors agree that patients whose ASA score is greater than 2 have a greater risk of SSIs (16). In our study, SSIs were registered almost three times more frequently in patients with a score ASA4, as compared to other patients ($p = 0.027$; $OR = 2.852$, 95% $CI = 1.125$ to 7.227).

SSIs did not occur with the same frequency in all departments. In our study, the highest percentage was registered at the Department of General and Abdominal Surgery (38.1%), following the Department of Traumatology (12.1%) and the Department of Vascular Surgery (11.6%).

The emergence of the SSIs was accompanied with the stay in the intensive care unit longer than one day ($p = 0.000$; $OR = 3.879$; 95% $CI = 1.996$ to 7.540). The risk was increased with the length of stay in the intensive care unit ($p = 0.006$; $OR = 1.334$; 95% $CI = 1.088$ to 1.636).

In the study conducted by Pereira and associates, it was established that the patients who had pre-operatively stayed in hospital longer than 4 days acquired SSIs three times more frequently ($OR=3.3$) (17).

Furthermore, there are authors who advocate non-removal of hair from the surgical site since the lowest rates of infection were in patients who did not have their hair removed (18). Our study confirmed that preoperative hair removal

carries the risk of SSIs ($p = 0.009$, $OR = 1.913$; 95% $CI = 1.172$ to 3.122), which was also increased with the prolonged time from hair removal to surgery ($p = 0.040$; $OR = 1.036$; 95% $CI = 1.002$ to 1.071).

Length of surgery is directly related to the risk of the occurrence of SSIs. In our study, the length of the operation was statistically significant with respect to the development of SSIs ($p = 0.000$; $OR = 1.006$; 95% $CI = 1.003$ to 1.009).

In the study conducted by Han and associates, intraoperative contamination was determined as a risk factor for the development of SSIs ($OR=10.549$, $p = 0.000$) as well as the "open" surgery in relation to laparoscopic surgery ($OR=2.111$, $p = 0.001$) (19). Analysis of risk factors with the use of univariate logistic regression in our study showed a correlation of SSIs with the degree of contamination ($p = 0.005$, $OR = 1.517$; 95% $CI = 1.137$ to 2.025).

In the prospective cohort study, conducted by Suljagic, it was determined that the risk for the development of SSIs increased with the NNIS index ($OR: 1.3$; 95% $CI: 1.063-1.7$). In our study, the results of univariate logistic regression showed that the NNIS index 0 had a protective role ($p = 0.013$), while for the rest of the index values, there was no statistically significant difference (20).

Previous studies on the role of drainage in the development of SSIs have yielded contradictory results. Some previous observational and experimental studies have shown that the presence of drainage represents a risk for the occurrence of SSIs, as it acts as a foreign body and reduces the local defense of the tissue (21). In some later studies, the connection between the use of drainage and occurrence of SSIs was not confirmed (22). In their meta-analysis, Diener and associates established that the intra-abdominal abscess occurred less frequently in cases when the drainage had been removed earlier (3-4 days) in relation to the removal in ≥ 5 days upon the insertion. ($OR 0.26$; 95% $CI=0.07-1.00$; $P = 0.05$) (23). However, univariate logistic regression showed that the occurrence of SSIs was associated with the length of the drainage ($p = 0.000$, $OR = 1.165$, 95% $CI = 1.105$ to 1.229), while multivariate regression did not show the independence of this factor.

Pittet and colleagues singled out the corticosteroid therapy as a risk factor for the occurrence of HAIs in hospitals in Switzerland, but the independence of the risk factor for the development of HAI was not confirmed by the multivariate regression analysis (24). In the study conducted by Fukuda, a statistically significant relationship between the use of corticosteroids and the occurrence of SSIs for cholecystectomy ($OR 2.83$; $P = 0.003$) and colon surgery was showed ($OR 1.27$, $P = 0.040$) (25).

In our study, there was a statistically significant difference in the incidence of corticosteroid therapy in patients with SSIs, compared to those without SSIs ($p = 0.010$, $OR = 4.160$, 95% $CI = 1.399$ to 12.367). In multivariate logistics regression, corticosteroids remained an independent risk factor for the development of SSIs ($p = 0.023$, $OR = 4.141$, 95% $CI = 1.221$ to 14.047).

Postoperative wound opening represents an additional risk for the operated patients. In our study, patients who had undergone the postoperative wound opening were almost 40 times more likely to have acquired SSIs as compared to patients whose wounds were not opened postoperatively (p

= 0.000; OR = 39,961, 95% CI = 12.203 to 130.860). Postoperative wound opening remained an independent risk factor, and patients who had undergone the re-intervention were 22 times more likely to have acquired SSIs than those without the re-intervention ($p = 0.000$; OR = 22,409, 95% CI = 1.221 to 14.947).

6. CONCLUSION

The incidence of SSIs at the Surgical Clinics of the University Clinical Centre Banja Luka is at the level of hospitals in developed countries.

There are a number of risk factors for SSIs, which may be prevented.

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