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Preliminary data from a surveillance study on surgical site infections and assessment of risk factors in a university hospital

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Aim: Surgical site infections (SSIs) lead to substantial mortality, morbidity, and socioeconomic loss. To explore the rate of infections and risk factors for the development of infection in surgical units.

Materials and methods: All patients (n = 1397) who underwent a surgical intervention and were hospitalized for >48 h in surgical units (except the ophthalmology unit) of Gaziantep University Medical Faculty Hospital between 17 March 2008 and 15 July 2008 were included in the study. The Center for Disease Control and Prevention criteria were used for identifying and diagnosing SSIs. Rate of SSI was calculated as the number of SSIs observed after every 100 surgical procedures. Potential risk factors for SSIs were evaluated by multivariate logistic regression model.

Results: SSIs occurred in 131 (9.4%) of the 1397 patients during this period. SSIs extended length of stay by 12.8 days. In the multivariate logistic regression analysis, diabetes mellitus (OR: 2.660, CI: 1.389–5.093), use of surgical drains (OR: 3.706, CI: 1.910–7.191), perioperative transfusion (OR: 1.787, CI: 1.077–2.965), trauma (OR: 2.244, CI: 1032–4.880), reoperation (OR: 7.408, CI: 3.315–16.555), contaminated (OR: 3.291, CI: 1.433–7.556) or dirty-infected (OR: 3.451, CI: 1.888–6.310) wound types, and each point increase in the National Nosocomial Infection Surveillance (NNIS) risk index (OR: 7.499, CI: 4.336–12.967) were detected as independent risk factors for developing SSIs.

Conclusion: In an effort to decrease SSI rate, risk factors should be determined and essential measures should be implemented regarding preventable factors. In this context, the excess transfusion of blood and blood products and unnecessary use of surgical drains should be avoided, and surgical drains should be removed as soon as possible. In addition, traditional wound classification and NNIS risk index may be used in the prediction of SSIs.

Key words: Surgical site infection, risk factors

1. Introduction

Observations during the past 30 years revealed that surgical site infections (SSIs) are responsible for a quarter of overall hospital infections (1). SSIs are the most significant and preventable causes of morbidity and mortality in surgical patients (2). Duration of hospital stay is extended and treatment costs are increased in patients with SSIs; hence, SSIs lead to substantial economic losses (3). An efficient surveillance system was shown to provide an approximately one third decrease in the rate of SSIs (4). Various factors associated with microorganisms, surgical procedures, and patients play a role in the development of SSIs. It is well known that defining the risk factors has a significant influence on prevention of disease (5).

The objective of this study was to determine the rate of SSIs and risk factors for development of infections observed after surgical operations by using surveillance data from Gaziantep University Medical Faculty.

2. Materials and methods

2.1. Patients and study protocol

In the current study, initial 16-week data derived between 17 March 2008 and 10 July 2008 in the context of a first surveillance study on SSIs in Gaziantep University Medical Faculty were analyzed. Gaziantep University Medical Faculty Hospital is a training hospital with 950 beds, providing tertiary healthcare.

All patients who underwent a surgical operation in the surgery units of Gaziantep University Medical Faculty (excluding the Department of Ophthalmology) and were hospitalized for at least 48 h (1397 patients) were

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enrolled in the study. Patients discharged within 2 days of the surgical operation were excluded from the study. Surveillance was conducted by an infection prevention physician and an infection control committee nurse by an active, prospective, and patient-based method. All patients enrolled in the study were monitored during hospital stay; surveillance was not maintained after discharge from the hospital.

Center for Disease Control and Prevention (CDC) criteria were utilized to define SSIs (6). In order to determine the relevant risk factors, the study group of patients with SSIs was compared with the group of patients who did not develop SSIs.

Demographic features, risk factors that may be associated with infections, and features of the surgical procedures were recorded. The American Society of Anesthesiologists (ASA) score was used for assessment of physical status of the patients before surgery (ASA 1: "a normal healthy patient", ASA 2: "a patient with a mild systemic disease", ASA 3: "a patient with severe systemic disease", ASA 4: "a patient with a systemic disease that is a constant threat to life", ASA 5: "a moribund patient who is not expected to survive"). Rate of contamination and National Nosocomial Infection Surveillance (NNIS) risk index were recorded (Table 2).

Conformity of the selected prophylactic antimicrobial agent and duration of prophylaxis were evaluated as per the recommendations indicated in "Guidelines for Prevention of Surgical Site Infections" issued by the CDC in 1999.

2.2. Statistics

For demographic data and risk factors of all patients with and without SSIs, qualitative univariate data were compared by chi-square test and Fischer's exact test, while the comparison of quantitative data was performed using an independent samples t test. For risk factors with a P value < 0.05, correlation with SSI was defined by multivariate analysis using a logistic regression test (95% confidence interval, odds ratio).

2.3. Ethical committee approval

The current study was approved by the Medical Ethical Committee of Gaziantep University Medical Faculty.

3. Results

A total of 1397 patients in 10 different surgical clinics of Gaziantep University Medical Faculty were enrolled in the study. Distribution of patients in terms of relevant clinics is shown in Table 1.

Among the 1397 patients enrolled, SSIs developed in 131 cases and the rate of SSI was 9.4%.

Mean age of patients with SSIs was 48 ± 20.7, while mean age of patients without any SSI was 40.6 ± 22.4. The difference between mean ages of the groups was statistically significant (P < 0.001). In the SSI group, 85 patients were male and 46 were female; SSIs were significantly higher in males (P = 0.001).

Among patients who developed SSIs, mean duration of preoperative stay in hospital was 3.2 ± 4.4 days, while the corresponding value in the non-SSI group was 1.8 ± 2.6 days (P < 0.001).

Table 1. Distribution of patients and SSI rates in terms of departments.

Departments	Total patient number (n)	%	Number of patients with SSIs (n)	Rate of SSI %
General Surgery	328	23.5	39	11.9
Orthopedics	275	19.7	17	6.2
Cardiovascular Surgery	136	9.7	16	11.8
Obstetrics and Gynecology	133	9.5	7	5.3
Neurosurgery	110	7.9	10	9.1
Ear, Nose, and Throat Surgery	98	7.0	9	9.2
Urology	95	6.8	10	10.5
Thoracic Surgery	87	6.2	10	11.5
Plastic and Reconstructive Surgery	82	5.9	8	9.8
Pediatric Surgery	53	3.8	5	9.4
Total	1397	100.0	131	9.4

Diabetes, chronic renal failure, malignancy, smoking, presence of drain, perioperative transfusion, trauma, reoperation, accompanying distant infections, hospitalization in intensive care units (ICUs), and inappropriate prophylaxis duration and use of inappropriate prophylactic antimicrobials were significantly higher in patients with SSIs, as compared to the non-SSI group (Table 2). In the SSI group, number of drains was 1.7 ± 1.1 and duration of stay in ICUs was 1.5 ± 4.1 days, while the corresponding values in the non-SSI group were 0.8 ± 0.8 and 0.3 ± 1.2 days, respectively. Number of drains and duration of stay in ICUs was significantly higher in patients with SSIs ($P < 0.001$ and $P < 0.001$, respectively).

Rate of SSIs following open surgery was significantly higher than that observed after laparoscopic surgery ($P = 0.028$). In addition, rate of SSIs following emergency operations was significantly higher than that observed after elective surgical operations ($P = 0.014$). Mean duration of surgical operations in patients with SSIs was 197.0 ± 110.6 min, while the corresponding mean duration in non-SSI patients was 128.6 ± 84.1 min; a statistically significant correlation was found between development of SSIs and duration of operations ($P < 0.001$).

Rate of SSIs was significantly higher in patients with ASA 2 and ASA 3, as compared to ASA 1 ($P < 0.001$).

In order to determine independent risk factors for SSIs, a logistic regression test, a multivariate analysis, was performed for factors previously determined as significant in univariate analysis. Independent risk factors determined in the multivariate analysis are indicated in Table 4.

4. Discussion

SSI is one of the leading causes of mortality and morbidity in the postoperative period. In ICU patients SSIs are reported to comprise 13% of nosocomial infections (7,8). Rate of SSIs was 9.4% in the current study. Since surveillance was not maintained after discharge from the hospital, the actual SSI rate was estimated to be higher. In studys conducted in this country, the rate of SSIs is reported as 8.8%–14.1% (9,10). However, in studies compiling national multicenter surveillance study results from Spain, France, and the USA, rates of SSIs were reported as 5.3%, 3.4%, and 2.6%, respectively (11–13). The lower rates observed in these countries, as compared to the results of the current study, may be due to the fact that this was the first surgical site surveillance performed in our hospital while similar studys were being conducted more efficiently for many years in these countries and appropriate SSI control measures were put in force following interpretation of surveillance data.

In our study, a significant correlation was detected between age and SSIs in univariate analysis. This finding may be explained by the presence of a number of accompanying diseases and decreased host defense in elderly patients. Although sex was indicated to have no impact on development of SSIs in several reports, development of SSIs in males in the current study was significantly high in univariate analysis (14,15).

Similar to the study conducted by Roumbelaki et al. (16), the results of our study showed that longer durations of preoperative hospitalization were significantly correlated with SSIs in univariate analysis. The mechanism responsible for the increase in risk of infection in parallel to duration of preoperative hospitalization is not fully described but longer hospitalization time may be associated with alterations in the endogenous flora of patients and with colonization of pathogen microorganisms, leading to SSIs.

The impact of diabetes on development of SSIs is controversial. In a prospective 5-year study conducted by Malone et al. (17) in noncardiac surgical patients, a significant correlation was determined between diabetes and SSIs, with the latter being 1.5-fold more common in diabetic patients compared with controls. In our study diabetes was specified as an independent risk factor in multivariate analysis and presence of diabetes was found to increase development of SSIs by 2.7-fold.

Use of drains in surgical patients is fairly common. Similarly, drains were present in 831 of the 1397 patients (59.5%) in the current study. Rate of SSIs in patients with drains was significantly higher than that in patients with no drains and a significant correlation was found between SSIs and increase in number of drains. As found in our study, presence of drains was reported to be an independent risk factor for SSIs in other studys (15,18).

Immunosuppressive action of perioperative blood transfusions was reported in previous studys and a 3-fold increase was found in posttransfusion nosocomial infection rates in a meta-analysis performed by Hill et al. (19). Similarly, our results indicate that perioperative transfusion is significantly correlated with SSIs in univariate analysis and it was specified as an independent risk factor in multivariate analysis. On the other hand, guidelines issued by the CDC conclude that, based on epidemiological data, the available information is insufficient to implement limitations in use of blood and blood products with the aim of preventing and decreasing development of SSIs (6).

In a study conducted by Sohn et al. (20) in 1999 in 391 patients, development of SSIs was observed in 35 of 151 trauma patients and trauma was indicated as an independent risk factor for SSIs. In the current study, SSIs developed in 21.5% of 107 trauma patients and a significantly higher rate of SSIs was determined in this group, as compared to patients with no history of trauma. Trauma was specified as an independent risk factor for SSIs and a 2.2-fold increase in SSIs was shown by trauma. We may associate this finding with the increase in

Table 2. Qualitative risk factors in development of SSIs.

Factors	Classification	Surgical site infection				Total		X^2 test P value
		Yes		No				
		n	%	n	%	number	%	
Sex	Male	85	64.9	621	49.1	706	50.5	=0.001*
	Female	46	35.1	645	50.9	691	49.5	
Diabetes	Yes	27	21.8	97	78.2	124	8.9	<0.001*
	No	104	8.2	1169	91.8	1273	91.1	
CRF	Yes	4	28.6	10	71.4	14	1.0	=0.035*
	No	127	9.2	1256	90.8	1383	99.0	
CAD	Yes	12	14.0	74	86.0	86	6.2	=0.129
	No	119	9.1	1192	90.9	1311	93.8	
HT	Yes	26	11.1	208	88.9	234	16.8	=0.326
	No	105	9.0	1058	91.0	1163	83.2	
COPD	Yes	6	10.9	49	89.1	55	3.9	=0.637
	No	125	9.3	1217	90.7	1342	96.1	
Malignancy	Yes	34	17.6	159	82.4	193	13.8	<0.001*
	No	97	8.1	1107	91.9	1204	86.2	
CHF	Yes	4	17.4	19	82.6	23	1.6	=0.264
	No	127	9.2	1247	90.8	1374	98.4	
Chronic liver disease	Yes	2	13.3	13	86.7	15	1.1	=0.644
	No	129	9.3	1253	90.7	1382	98.9	
Smoking	Yes	33	14.0	202	86.0	235	16.8	=0.01*
	No	98	8.4	1064	91.6	1162	83.2	
Obesity	Yes	2	4.0	48	96.0	50	3.6	=0.317
	No	129	9.6	1218	90.4	1347	96.4	
Drain	Yes	112	13.5	719	86.5	831	59.5	<0.001*
	No	19	3.4	547	96.6	566	40.5	
Prosthesis	Yes	16	7.8	188	92.2	204	14.6	=0.515
	No	115	9.6	1078	90.4	1193	85.4	
Transfusion	Yes	83	18.4	368	81.6	451	32.3	<0.001*
	No	48	5.1	898	94.9	946	67.7	
Trauma	Yes	23	21.5	84	78.5	107	7.7	<0.001*
	No	108	8.4	1182	91.6	1290	92.3	
Reoperation	Yes	24	49.0	25	51.0	49	3.5	<0.001*
	No	107	7.9	1241	92.1	1348	96.5	
Distant infection	Yes	10	41.7	14	58.3	24	1.7	<0.001*
	No	121	8.8	1252	91.2	1373	98.3	
Stay in ICU	Yes	45	18.0	205	82.0	250	17.9	<0.001*
	No	86	7.5	1061	92.5	1147	82.1	
Prophylactic antimicrobial	Inappropriate	36	10.8	297	89.2	333	27.5	<0.001*
	Appropriate	43	4.9	834	95.1	877	72.5	
Duration of prophylaxis	Inappropriate	80	6.9	1060	93.1	1140	94.2	=0.019*
	Appropriate	0	0	70	100.	70	5.8	
Type of surgery	Open	131	9.7	1225	90.3	1356	97.1	=0.028*
	Laparoscopic	0	0.0	41	100.	41	2.9	
Status of surgery	Emergency	16	17.6	75	82.4	91	6.5	=0.014*
	Elective	115	8.8	1191	91.2	1306	93.5	
Anesthesia	General	121	9.7	1128	90.3	1249	89.4	=0.508
	Local	1	5.9	16	94.1	17	1.2	
	Spinal-Epidural	9	6.9	122	93.1	131	9.4	
ASA	1	17	3.9	415	96.1	432	30.9	<0.001*
	2	69	8.8	711	91.2	780	55.8	
	3	45	24.9	136	75.1	18	13.0	
	4	0	0.0	4	100	4	0.3	
Wound type	Clean	34	4.4	738	95.6	772	55.3	<0.001*
	Clean-contaminated	45	9.8	414	90.2	459	32.9	
	Contaminated	25	30.1	58	69.9	83	5.9	
NNIS risk	Dirty-infected	27	32.5	56	67.5	83	5.9	<0.001*
	–1	0	0.0	21	100	21	1.5	
	0	7	1.1	646	98.9	653	46.7	
	1	57	10.1	506	89.9	653	40.3	
	2	54	36.7	93	63.3	147	10.5	
	3	13	100.	0	0.0	13	0.9	

X^2: Chi-square test, **CRF**: Chronic renal failure, **CAD**: Coronary artery disease, **HT**: Hypertension, **COPD**: Chronic obstructive pulmonary disease, **CHF**: Congestive heart failure *$P < 0.05$ = statistically significant

Table 3. Quantitative risk factors in development of SSIs.

Factors	Surgical site infection		Total	Independent samples t-test
	Yes	No		
Age (years)	48.1 ± 20.7	40.6 ± 22.4	41.3 ± 22.4	<0.001*
Preoperative hospitalization (days)	3.2 ± 4.4	1.8 ± 2.6	1.9 ± 2.9	<0.001*
Number of drains	1.7 ± 1.1	0.8 ± 0.8	1.5 ± 0.7	<0.001*
Stay in ICU (days)	1.5 ± 4.1	0.3 ± 1.2	2.4 ± 3.5	<0.001*
Duration of operation (min)	197.0 ± 110.6	128.6 ± 84.1	135.0 ± 89.1	<0.001*

ICU, intensive care unit
*P < 0.05 = statistically significant

Table 4. Independent risk factors for SSIs in multivariate analysis.

Factors	P value	Odds ratio (OR)	95% Confidence interval (CI)
Diabetes	0.003	2.660	1.389–5.093
Drain	<0.001	3.706	1.910–7.191
Perioperative transfusion	0.025	1.787	1.077–2.965
Trauma	0.041	2.244	1.032–4.880
Reoperation	<0.001	7.408	3.315–16.555
Wound classification			
Clean			Reference
Clean-contaminated	0.920	1.052	0.391–2.830
Contaminated	0.005	3.291	1.433–7.556
Dirty-infected	<0.001	3.451	1.888–6.310
NNIS risk index (reference –1)	<0.001	7.499	4.336–12.967

contamination rate of wounds related to trauma and with emergency surgical interventions frequently performed following trauma.

In a 12-month prospective study conducted in France in 1268 patients, reoperation was indicated as an independent risk factor in SSIs observed following cardiac surgery (21). Similarly, in the current study, a significant correlation was found between reoperation and SSIs in univariate analysis and reoperation was determined as an independent risk factor for development of SSIs in multivariate analysis. Regardless of cause, re-opening of an incision increases the probability of wound contamination, which clearly demonstrates the mechanism of reoperation presenting as a risk factor for SSIs.

In the current study, prophylaxis was not administered in 1.7% of clean-contaminated operations, an inappropriate antimicrobial was selected in 27.5%, single-dose prophylaxis was used during induction of anesthesia in only 0.8%, and only 4.9% of patients received <24-h prophylaxis, while 94.2% received >24-h prophylaxis. The most commonly used prophylactic agents were cefazolin (53.1%), cefuroxime axetil (17.8%), and third generation cephalosporins (8.5%). In addition, a significant correlation was found between inappropriate antimicrobial selection and inappropriate duration of prophylaxis (longer than 24 h) and SSIs in univariate analysis. Results reported in other studies also support the significant correlation between development of SSIs and prolonged antimicrobial prophylaxis (22,23).

In a study conducted in a 750-bed university hospital in Thailand by Narong et al. (24), rate of SSIs was determined as 2.3% in clean wounds, 4.8% in clean-contaminated

wounds, 14.9% in contaminated wounds, and 26% in dirty-infected wounds; as compared to clean wounds, the last 3 wound types were reported as independent risk factors for development of SSIs. In the current study, rate of SSIs was 4.4% in clean wounds, 9.8% in clean-contaminated wounds, 30.1% in contaminated wounds, and 32.5% in dirty-infected wounds. Contamination rate of wounds was specified as an independent risk factor for SSIs in a number of studys (8,15,18,24). In our study, contaminated and dirty-infected wounds were independent risk factors for SSIs as compared to clean wounds in multivariate analysis, while we were unable to specify clean-contaminated wound as an independent risk factor. Contaminated wounds were found to increase the rate of SSIs by 3.3-fold, while dirty-infected wounds led to an increase of 3.5-fold.

In the study entitled "Performance of NNIS risk index in prediction of surgical site infections in Australia", a positive correlation was found between NNIS risk index and increased rate of SSIs (25). In the current study, rate of SSIs was determined as 0.0%, 1.1%, 10.1%, 36.7%, and 100.0% as per the NNIS risk index (–1, 0, 1, 2, 3), respectively. Development of SSIs was observed in all 13 patients with a NNIS risk index of 3. In univariate analysis, a statistically significant correlation was found between SSIs and each of the factors constituting the NNIS risk index (surgical wound type, ASA score, duration of surgical operation, laparoscopic surgery) as well as the NNIS risk index itself. As seen in the study performed by Petrosillo et al. (15), our study results indicate NNIS risk index as an independent risk factor for SSIs. Regarding patients with a NNIS risk index of –1 as the reference point, the probability of SSIs increases by 7.5-fold with each 1 point increase in the NNIS risk index.

The following conclusions were drawn:

1. Surveillance for SSIs is recommended for each center to determine the rate of SSIs, distribution of agent microorganisms, and antimicrobial sensitivities of microorganisms. Empirical treatment of SSIs should be conducted using these relevant data.
2. In order to compare rate of SSIs with rates indicated in other centers and presented as national values, surveillance of SSIs should be performed in compliance with standard definitions.
3. Duration of preoperative hospitalization and stay in ICUs should be kept at a minimum to decrease rate of SSIs.
4. In patients specified as candidates for elective surgery, smoking should be stopped, problems that may require blood and blood product transfusions should be corrected, and distant infections, if any, should be treated prior to surgical operations.
5. In order to prevent development of SSIs, perioperative blood and blood product transfusions and number of drains should be kept at a minimum and unnecessary use of drains should be avoided.
6. In patients specified as candidates for surgical operations, antimicrobial prophylaxis should be administered based on appropriate indications, with an appropriate antimicrobial for an appropriate duration.
7. For the purpose of preventing SSIs, suitable operations should be performed laparoscopically.
8. Conventional wound classification and NNIS risk index may be utilized in prediction of SSIs.
9. Further long-term studys evaluating other factors in addition to the parameters indicated in this study are required to fully specify SSI risk factors and to prevent development of infections.

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