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Risk Factors in Surgical Site Infections

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Abstract

Purpose of the Research: Our study aimed to determine and understand the risk factors of surgical site infections in patients operated on in general surgery wards. **Method of Research:** Between May 2008 and November 2008, 422 consecutive patients who underwent emergency and elective surgeries, excluding breast, goitre and laparoscopic surgeries, were included in the study to determine surgical site infections and risk factors. The patients' risk factors were selected in the preoperative period, and postoperative 3rd, 7th, and 30th days were checked by the physician responsible for conducting the study regarding surgical site infection. **Results and Conclusion:** Surgical site infections were defined as incisional and organ/space based on NNIS data. Gender, diabetes mellitus, malignancy, degree of contamination, ASA score ≥ 3, preoperative skin cleansing, duration of intensive care unit stay, duration of hospital stay, growth in wound culture, duration of surgery and incision length were determined as risk factors increasing CAI rates. Especially the degree of contamination, duration of intensive care unit stay, hospitalisation, duration of operation, and growth in wound culture were decisive factors in the development of CAI. As a result of our study, in the light of these data, we concluded that to prevent the development of CAI can be modified, interventions to foreseeable factors can be assessed.

Keywords

Infection, CAI, Risk, Patient

1. Introduction

It is observed as a systemic or localised infection that develops from the admission of the patients to the hospital and is not in the incubation period at the time of admission or sometimes occurs after discharge. However, it develops in the hospital due to toxins or infectious agents. The incubation phase varies according to the causative microorganism. Infections that develop 48 - 72 hours after hospitalisation and within ten days after discharge are analysed in this group [1]. Some sources accept Infections that form within 72 hours after discharge as nosocomial infections [2] [3].

Surgical incisions commonly cause sterile tissues to come into contact with the non-sterile environment, and contamination occurs. This contamination is not prevented even with the best surgical technique and aseptic conditions. In addition, surgical trauma and anaesthesia increase the risk of infection by affecting the patients' systemic defence mechanisms. For this reason, when cases that have undergone surgical intervention are analysed, surgical site infection (SSI) may develop if necessary precautions are not taken [4].

Surgical site infections can develop within 30 to 90 days following surgical intervention and are defined as incision, organ space and organ infections with a very high mortality and morbidity rate [5]. Surgical site infections are the second most common after urinary tract infections, with a frequency of 14% - 16% [6]. Surgical patients have more complex comorbidity, the treatment of surgical site infections becomes more complex, and cost increases with the emergence of antimicrobial-resistant pathogens [7] [8] [9] [10].

Surgical site infections are a significant cause of morbidity and mortality. Surgical site infections are more frequently caused by Gram (+) bacteria in the skin flora, and Gram (−) and fungal infections are observed. It has been determined that colonisation and related surgical site infections are observed, primarily due to resistant pathogens. Surgical site infections mainly cause patients to stay in the hospital for a long, increasing treatment costs with antibiotic use and causing a loss of labour force [11] [12].

Patient-dependent factors (age, body mass index, malnutrition, smoking, etc.), surgical factors (surgical site, technique, duration and contamination level of the wound) and environmental factors determine the factors that cause surgical site infections to occur [13]. Therefore, predisposing factors affecting the development of surgical site infections should be known, and necessary precautions should be taken.

Antisepsis rules defined in the nineteenth century and antibiotics developed afterwards have led to a decrease in the rate of CAI. However, it is seen that unconscious use of antibiotics by patients and errors in surgical interventions increase the rate of CAI despite advanced surgical techniques and technology. It has been determined that there are many risk factors related to the surgical technique, operation process and patient in the occurrence of CAI [14]. It is thought that the increase in resistant microorganisms, increase in the elderly patient population with underlying chronic disease and immunosuppression, increase in the life span of patients, increase in surgical intervention opportunities and prosthetic applications and organ transplantations affect the development of CAI [15]. The primary source of microorganisms causing CAI is seen as endogenous flora. Microorganisms found in the patient's skin and mucosa have been determined to be the most important causes of infection agents. The most frequently isolated pathogens from CAI are Staphylococcus aureus, coagulase-negative staphylococci, enterococci and Escherichia coli. Microorganisms such as methicillin-resistant S. aureus and Candida albicans are also often observed [16].

In recent years, it has been determined that antibiotic resistance has been observed at increasing rates in bacteria isolated from wound cultures as infection agents. Therefore, periodic monitoring of microorganism species is essential in units where the wound infection rate is high [17]. It has been the focal point of surgical research because it is a significant cause of mortality, morbidity and increased costs in determining the risk factors for the development of CAI [18]. Therefore, it is necessary to know the risk factors and take precautions to protect from CAI, which continues to be one of the most critical problems of modern surgery [19].

2. Material and Method

Between May 2008 and November 2008, 422 consecutive patients who underwent emergency and elective surgeries, excluding breast, goitre and laparoscopic surgeries in Dokuz Eylül University Faculty of Medicine, Department of General Surgery, were included in a prospective clinical study to determine surgical site infections and risk factors. The inclusion criteria were patients who underwent emergency and elective surgery except for breast, goitre and laparoscopic surgery. The exclusion criterion was that these patients were younger than 18. No financial support was received in this study. Surgical site infections were defined as incisional and organ/space based on NNIS data. Patient characteristics: age, gender, smoking (pack/day), body mass index, subcutaneous tissue thickness (cm), alcohol use (social drinker-daily alcohol user), steroid and immunosuppressive use (for chronic medical conditions), diabetes mellitus (diet-regulated-insulin user-oral diabetic user-blood glucose <130), chronic obstructive pulmonary disease (COPD), congestive heart failure (class I - class II - class III - class IV according to NYHA), cancer, malnutrition (weight loss of more than 10% in the last six months preoperatively or serum albumin levels < 3 g/dl), preoperative bilirubin, preoperative hospital stay, preoperative or postoperative anaemia (Hb < 10 mg/dl), blood product transfusion, coronary artery disease and previous myocardial infarction, previous abdominal surgery, presence of preoperative malignancy, preoperative chemotherapy, preoperative radiotherapy, and preoperative systemic infection. Characteristics related to the operation process were determined and evaluated as the type of operation performed, duration of the operation, degree of contamination (clean, clean-contaminated, contaminated, dirty), whether the operation was emergency or elective, prop skin cleaning, duration of surgical washing (5 min, less than 5 min), length (cm) and type of surgical incision, postoperative intensive care unit (days) and hospital stay (days), postoperative ward stay (days). The height and weight of all patients were measured preoperatively and at follow-up, and body mass index (BMI) was calculated by the formula Body Mass Index (BMI) = Weight (kg) / Height (m^2). Haemogram, routine biochemistry, bleeding and coagulation times were measured, and electrocardiography and postero-anterior chest radiography were performed preoperatively in all patients.

Statistical Analyses

SPSS (Statistical Package for Social Sciences) for Windows 26.0 program was used for statistical analyses of the data obtained in the study. The x^2 test and Fisher's exact test were used to compare the data qualitatively. The results were evaluated at a 95% confidence interval and significance level of $p < 0.05$.

3. Findings

3.1. General Information about Patients

Among the patients, 37.9% (160 individuals) were female and 62.1% (262) were male. Four per cent (17 patients) were 19 years of age or younger, 19.4% (82 patients) were aged 20 - 34 years, 22.9% (97 patients) were aged 35 - 49 years, 27.9% (118 patients) were aged 50 - 64 years, 21.09% (89 patients) were aged 65 - 79 years, and 4.5% (19 patients) were aged 80 years or older. The number of emergency-operated patients was 152 (36%), and the number of elective-operated patients was 270 (64%). While 28.6% of the patients were smokers, 71.4% were non-smokers. The measurements revealed that 3% (13 patients) were underweight, 47.3% (200 patients) were average weight, 35.3% (149 patients) were overweight, 13.9% (59 patients) were obese, and 0.2% (1 patient) were severely obese. While 18% of the patients used alcohol, 82% did not use alcohol. According to the data obtained from the anamnesis, only 0.5% of the patients had collagen tissue disease, 11.1% (47 patients) had received chemotherapy (CT), and 5.2% (22 patients) had received radiotherapy (RT). Steroid therapy was used in 6.8% (29 patients) and immunosuppressive treatment in 8.3% (35 patients). The number of patients with previous abdominal surgery was 101 (23.9%), and the number of patients without previous abdominal surgery was 321 (76.1%). Coronary artery disease (CAD) was present in 11.6%, diabetes mellitus (DM) in 19.6%, heart failure (HF) in 8.3%, and chronic obstructive pulmonary disease (COPD) in 5.6% (**Table 1**).

Biochemical parameters (haemogram and extensive biochemistry) showed that 21.8% of the patients had low serum albumin levels (<3 g/dl), and 78.2% had normal serum albumin levels (>3 g/dl). Haemoglobin (Hb) values were common (<10 g/dl) in 18.9% of the patients, and Hb values were within normal limits in 81.1%. Instructors performed 335 (79.4%) patients' operations and 87 (20.6%) by residents. In 421 patients, the surgical washout time was 5 minutes, while in only one patient, the surgical washout time was less than 5 minutes. Perioperative skin cleansing was performed in 99.2% (419) of the patients, and only 0.7% (3 patients) did not undergo perioperative skin cleansing. When we looked at the incision lengths of the patients, 136 patients (32.4%) had an incision length

Table 1. Distribution of descriptive characteristics.

Variable	Frequency (f)	Percentage (%)
Age		
19 years of age or younger	17	4
20 - 34 years	82	19.4
35 - 49 years	97	22.9
50 - 64 years	118	27.9
65 - 79 years	89	21.09
80 years or older	19	4.5
Gender		
Female	160	37.9
Male	262	62.1
Smokers	121	28.6
Alcohol	76	18
KAH	49	11.6
KY	35	8.3
DM	83	19.6
COPD	24	5.6
Malignancy	150	35.5
KT	47	11.1
RT	22	5.2
Previous abdominal op.	101	23.9
Steroid therapy	29	6.8
Immunosuppressive therapy	35	8.3
Emergency	141	33.4
Elective	281	66.5
Collagen tissue disease	2	0.5

between 4 - 13 cm, 129 patients (30.7%) had an incision length between 14 - 23 cm, 103 patients (24.3%) had an incision length between 24 - 32 cm, 47 patients (10.9%) had an incision length between 33 - 42 cm, and seven patients (1.4%) had an incision length between 43 - 52 cm. The subcutaneous tissue thickness of 55 patients (13.03%) was between 0 - 2 cm, 310 patients (74.4%) were between 3 - 5 cm, 55 patients (13.03%) were between 6 - 8 cm, and two patients (0.5%) were between 9 - 11 cm.

The patients were classified according to the degree of contamination: 120 patients (28.4%) had clean wounds, 231 patients (54.7%) had clean-contaminated wounds, 51 patients (12.1%) had contaminated wounds, and 20 patients (4.8%)

had dirty wounds. When the contamination degrees were generally analysed, a cluster was observed in the clean-contaminated wound group (54.7%) (**Table 2**).

Regarding ASA scoring, 115 (27.3%) of the patients had ASA score 1, 167 (39.6%) had ASA score 2, 108 (26.6%) had ASA score 3, and 32 (7.6%) had ASA score 4.

3.2. Results of Parameters Related to Patients

Surgical site infection developed in 64 (15.1%) of 422 patients included in the study. Of the patients who developed CAI, 17 were female, and 47 were male. CAI was significantly more common in male patients (95% confidence interval, p = 0.042). Pearson chi-square analysis revealed no significant relationship between age groups and CAI (p = 0.112). No significant correlation was found between body mass index and CAI development (p = 0.440), but CAI development was observed more in obese patients. There was no relationship between coronary artery disease and CAI (p = 0,794). CAI developed in 30 (36%) of 83 patients with diabetes mellitus, whereas CAI developed in 49 (14.4%) of 339 patients without DM, and a significant relationship was found between DM and CAI (p = 0.02). There was no significant association between HF and CAI (p = 0.107). There was no meaningful relationship between COPD and CAI (p = 0.754). No significant difference was observed between smokers and non-smokers in terms of CAI (p = 0.877).

There was no significant relationship between alcohol use and CAI (p = 0.119). There was no meaningful relationship between collagen tissue disease and CAI (p = 0.548). There was no significant relationship between patients with and without previous intra-abdominal surgery regarding CAI (p = 0.192). When patients with malignancy were compared with patients without malignancy, there was a significant difference between the groups regarding CAI (p = 0.019), and CAI was significantly higher in patients with malignancy. No significant correlation was found between patients who received chemotherapy and radiotherapy and those who did not (p values 0.359 and 0.415, respectively). There was no significant difference in CAI between patients who received steroid and immunosuppressive therapy and those who did not (p = 0.104). No difference was found in terms of CAI between normal and low (<3 g/dl) albumin values (p = 0.738). There was no correlation between subcutaneous tissue thickness and

Table 2. Contamination degree.

	Number of patients	Percentage (%)
Clean	120	28.4
Clean-contaminated	231	54.7
Contaminated	51	12.1
Dirty	20	4.8
Total	422	100

CAI (p = 0,773). No significant difference was found between normal and low (<10 g/dl) Hb values in terms of CAI (p = 0.506) (Table 3).

Table 3. Relationship between patient characteristics and surgical site infection

		CAİ (+)	CAİ (−)	P value*
Patient's gender (n = 422)	Female	17	143	0.042
	Male	47	215	
Age (n = 422)	19 years of age or younger	1	16	0.176
	19 - 34 years	6	76	
	35 - 49 years	16	81	
	50 - 65 years	19	99	
	65 - 79 years	18	71	
	80 years or older	4	15	
BMI (n = 422)	Weak	2	11	0.449
	Normal	27	173	
	Overweight	21	128	
	Obese	14	45	
	Advanced Obese	0	1	
CAD (n = 422)	+	8	42	0.794
	−	56	316	
HF (n = 422)	+	2	34	0.107
	−	62	324	
COPD (n = 422)	+	3	21	0.754
	−	61	337	
LatC abd.op (n = 422)	+	19	84	0.192
	−	45	274	
KT (n = 422)	+	5	42	0.359
	−	59	316	
RT (n = 422)	+	2	20	0.415
	−	62	338	
Immunosuppressive (n = 422)	+	2	33	0.104
	−	62	325	
Smoking (n = 422)	+	19	102	0.877
	−	45	256	
Alcohol (n = 422)	+	16	60	0.119
	−	48	298	

Continued

Subcutaneous tissue thickness in centimeters (n = 422)	0 - 2 cm	8	47	0.773
	3 - 5 cm	48	262	
	6 - 8 cm	8	47	
	9 - 11 cm	0	2	
DM (n = 422)	+	30	83	0.02
	−	49	260	
Hb (n = 422)	<10 g/dl	10	70	0.506
	>10 g/dl	54	288	
Alb (n = 422)	<3 g/dl	15	77	0.738
	>3 g/dl	49	281	
Malignancy (n = 422)	+	31	119	0.019
	−	33	239	

*P value < 0.05 significant.

3.3. Results of Parameters Related to Operative Process

A significant correlation (p = 0.002) was observed between the degree of contamination and CAI, with CAI rates of 5% in clean wounds, 17% in clean-contaminated wounds, 27% in contaminated wounds and 21% in dirty wounds. The incidence of CAI was significantly higher in patients with an operation time of more than 2 hours (p = 0.016). When we compared emergency operations, no significant relationship was found regarding CAI (p = 0.911). When we reached patients who underwent preoperative skin cleansing with patients who did not, CAI was significantly higher in patients who did not undergo skin cleansing (p = 0.013). There was no correlation between CAI and duration of surgical washing (p = 0.674). Whether the surgeon was a lecturer or assistant did not pose a significant risk for CAI (p = 0.284). A highly effective relationship was found between CAI and the duration of intensive care unit stay (p < 0.0001). CAI was significantly higher in patients who received a blood transfusion in the perioperative period (p = 0.002). While there was no correlation between preoperative hospitalisation time and CAI (p = 0.284), there was a significant correlation between postoperative hospitalisation time and CAI (p < 0.0001). CAI was significantly higher in patients with wound culture growth (p < 0.0001). There was a significant correlation between incision length and CAI (p = 0.027) (**Table 4**). There was no correlation between subcutaneous tissue thickness and CAI (p = 0.773). According to the ASA scoring, CAI was observed at a higher rate in patient groups with ASA ≥ 3 (p = 0.034) (**Table 4**).

4. Discussion

According to the Centers for Disease Control and Prevention (CDC), CAI is an infection that develops within the first 30 - 90 days after surgery if no implant is

Table 4. CAI relationship of parameters related to operative process.

	CAİ (+)	CAİ (−)	*p Value
Degree of contamination			
Class 1 - 2	47	300	0.002
Class 3 - 4	17	48	
Total 412			
Duration of surgery			
<2 hours	48	280	0.016
>2 hours	16	68	
>Total 412			
Surgical washout time			
<5 minutes	0	1	0.0674
>5 minutes	64	357	
>Total 422			
Surgery			
Emergency	23	129	0.911
Elective	41	229	
Total 422			
Preop skin cleansing			
Made	62	357	0.013
Not made	2	1	
Total 422			
The surgeon			
Lecturer	54	281	0.284
Assistant	10	77	
Total 422			

*P value < 0.05 significant.

placed or within one year if an implant is placed and is related to the surgical intervention [20]. CAI is a severe and significant problem for surgery because it increases mortality, morbidity, hospitalisation time and cost [21] [22]. Although it is not possible to determine the exact rate of CAI, according to the US national data, the CAI rate was defined as 689.9/10,000 in 2010, and according to the CDC, approximately 290,000 CAI diagnoses annually cause an extra expenditure between 3.45 - 10.07 billion dollars [12].

Centres for Disease Control and Prevention classified postoperative infections as distant and surgical site infections. CAI is also classified as superficial, deep incisional and organ-void [23]. This definition compares data between hospitals and diagnosis of infections [24]. Surgical site infections (SSI) are the second or third most common nosocomial infections [16]. When extensive epidemiological studies were examined, it was found that CAI developed in at least 2% of all hospitalised operated patients. This rate is estimated to increase even more with post-discharge infections [25]. Accordingly, the incidence of CAI varies between 3% and 20% depending on the surgical procedure performed [26] [27].

The CDC Guideline endeavours to present all evidence-based data to surgeons worldwide to evaluate specific perioperative strategies, shaping the treatment and reducing CAI [28]. This study aimed to determine the parameters associated with CAI by making a general evaluation of the parameters that constitute risk factors in terms of CAI. As a result of evaluating the risk factors determined here, reducing the development of CAI may be possible. In this study, the risk factors related to the patient were determined as age, diabetes mellitus, gender, heart failure, COPD, etc., and the parameters related to the operation were determined as operation time, surgery, washing, hospitalisation time, degree of contamination, and ASA scoring.

In this study, the incidence of postoperative CAI due to all causes was 15.1%. In the study conducted by Watanabe *et al.* [29], the incidence of CAI was 15.5%, and in the survey conducted by Topaloğlu *et al.* [30], the incidence of CAI was 14.1%. It was found that all of the surgical site infections observed in the study were kept within thirty days after surgery [29] [31]. The guideline for preventing surgical site infections (CDC Guideline) defines CAI as wound infections developing within thirty days after surgery [23]. When the univariate analyses performed here were examined, it was found that gender, diabetes mellitus and malignancy were significantly associated with CAI.

Research [32] examined the relationship between CAI and gender in patients undergoing coronary artery bypass surgery. It was found that CAI was significantly higher in women. The reason why CAI is observed more in women after CAGB surgery is that their body mass and vessel diameters are more minor. In the study conducted by Kangrasi *et al.* [33], the rate of CAI in women was 10.8%, while this rate was 14.5% in men, and the p-value did not show significance. In our study, CAI was found to be 17.9% in men and 10.6% in women, and statistical significance was found between these values ($p = 0.042$).

In our study, it was determined that CAI was more common in the male patient group due to the lack of randomisation in terms of age, BMI and other comorbid conditions in both gender groups and the higher number of male patients. In the study, there were 19 male patients with a BMI over 25, whereas there were nine female patients with a BMI over 25. When the distribution of patients with diabetes mellitus was analysed, it was determined that the male population was higher (25 of 30 patients with diabetes mellitus who developed CAI were male and five were female). In conclusion, when the development of CAI is analysed, it is seen that gender, type of surgery and patient characteristics are effective. Randomised studies with larger populations evaluating gender and

CAI development are needed [34] and found that diabetes mellitus significantly increased the development of CAI (p = 0.008). In the study by Watanabe *et al.* [29], diabetes mellitus did not pose a risk for CAI. The effects of diabetes mellitus on CAI should be discussed. It was found that no independent risk factor could be determined in many studies. It has been determined that high HbA1C levels and high glucose levels (>200 mg/dl) may increase the risk of CAI [23]. HbA1C level gives information about whether diabetes mellitus is regulated or not. In our study, 30 (36.1%) of 83 patients with diabetes mellitus developed CAI, whereas 49 (18.8%) of 260 patients without diabetes mellitus developed CAI. A significant relationship was found between diabetes mellitus and CAI (p = 0.02). However, randomised studies with large populations must determine the relationship between diabetes mellitus and CAI [23].

In our study, malignancy, one of the patient-related factors, was found to be one of the independent risk factors for CAI. Malignancy impairs body defence and decreases body resistance against infections. It was determined that the risk of developing infection increased in patients with weakened body resistance after surgical procedures. Naturally, it is observed that the rate of infection development is higher in patients with malignancy. There is a need for randomised studies with larger populations examining the relationship between malignancy and CAI.

In the literature, it is seen that there are no studies including parameters such as the stage of the disease and the organ involved with CAI.

In our study, no significant relationship was found between smoking and alcohol use and development of CAI. In the survey conducted by Fiorio *et al.* [35], it was determined that there was no relationship between smoking and development of CAI. [36] examined the relationship between alcohol use and CAI in general surgical operations; it was found that CAI rates were significantly higher in patients with alcohol consumption > 72 grams per day. In contrast, patients with <10 gr/dl and >10 gr/dl per day were compared, and Hb was 10 gr/dl. Here, it is seen that the number of patients with Hb value < 10 gr/dl was only 80. As a result, CAI was observed more in the group with Hb < 10 gr/dl, but this difference was not statistically significant.

In the study conducted by Fiorio *et al.* [35], it was determined that there was no relationship between malnutrition and CAI, and no relationship was found between albumin level, which is an indicator of malnutrition, and CAI.

In our study, it was determined that subcutaneous tissue thickness did not increase the occurrence of CAI. It was determined that most of the patients in the study had a subcutaneous tissue thickness between 3 - 5 cm, and the number of patients with a subcutaneous tissue thickness of 9 - 11 cm was 2. In conclusion, randomised clinical studies with more patients are needed to examine the relationship between subcutaneous tissue thickness and CAI.

In our study, although CAI rates were higher in the patient group with previous abdominal surgery, no statistically significant difference was found. It is thought that statistically significant results can be obtained with new studies conducted by increasing the number of patients in the study. In previous studies, the degree of contamination was found to be an independent risk factor for CAI [29] [30] [37].

[31], it was determined that the degree of contamination was highly influential in the development of CAI (p < 0.0001). As a result, the analyses performed in the patient group we used in our study revealed a statistically significant relationship between the degree of contamination and the development of CAI (p = 0.002). Surgeons were advised to avoid contamination as much as possible during surgeries.

In our study, patients were grouped as 1, 2, 3, 4 according to ASA scoring and ASA 1, 2 and ASA 3, 4 groups were compared in terms of CAI. Significantly more CAI was observed in the ASA 3, 4 group. This result is generally compatible with the literature, and studies in the literature examined the relationship between ASA scoring and CAI. Still, no significant relationship was observed [29]. Watanabe *et al.* [29] evaluated the risk factors for CAI in gastrointestinal surgery. In this study, ASA 1, 2 and ASA 3, 4 were compared according to ASA scoring and no significant difference was observed between the groups. In the survey conducted by Topaloğlu *et al.* [30], it was determined that there was a substantial relationship between ASA scoring and CAI development in the evaluation of postoperative wound healing (p < 0.0001).

ASA scoring was evaluated as an independent risk factor in the development of CAI. [34] found that ASA scoring was determined as an independent predictor of CAI. In the patient group we studied, preoperative skin cleansing reduced the development of CAI. Several antiseptics (alcohol, chlorhexidine, iodine, iodophors, etc.) are recommended for preoperative skin preparation in the CDC Guideline, and it is emphasised that there are not enough studies comparing antiseptic agents in terms of skin cleansing [32]. Our study determined that the duration of intensive care unit stay and hospitalisation in the postoperative period significantly increased the development of CAI in the selected patient group (p < 0.0001). The study conducted by Sangrasi *et al.* [33] determined that the duration of postoperative hospitalisation was a risk factor for CAI. It was found that the average hospitalisation period of the group who developed CAI was 16.2 days. In comparison, the average hospitalisation period of the group who did not develop CAI was 6.3 days. In this study, it was determined that the duration of hospitalisation was more than twice as long in patients who developed infection. The results of our study are consistent with the results of this study. In our study, the duration of surgery, which was longer than 2 hours, also increased the risk of CAI (p = 0.016). Malone *et al.* [34] found that patients with an operation time of 4 hours were compared, and an increase in CAI rates (2.1%-3.3%-6.4%, respectively) was observed as the operation time was prolonged.

Preoperative surgical washing (forearm and hand) should be done carefully without wearing sterile gloves. In our study, surgical washing was performed appropriately, while surgical washing was performed in less than 5 minutes in only one patient. In our study, two groups, longer or shorter than 5 minutes, could not be formed, considering that it would not be appropriate to obtain patient consent both in terms of surgical ethics and for the surgical washing period, and no statistical comparison was made.

The CAI Risk Factors Reanalysis study conducted by Malone *et al.* [34] determined that emergency surgery was a significant risk factor for CAI ($p = 0.034$). In our research, it was determined that whether the operation was emergency or elective did not make a substantial difference in terms of CAI. Still, in our study, the number of patients who underwent emergency surgery was 152, while the number of patients who underwent elective surgery was 270. Although emergency surgery did not pose a significant risk in our study, emergency surgery was determined as an independent risk factor for CAI in previous studies [29] [34]. It may be appropriate to compare emergency and elective patients with more patients.

In our study, whether a lecturer or an assistant performed the surgery was evaluated in terms of CAI, and no difference was observed between the two groups in terms of CAI. In our study, the number of operations performed by assistants was only 87. In the CAI Risk Factors Reanalysis study conducted by Malone *et al.* [34], it was determined that there was no significant relationship between the length of preoperative hospitalisation and the development of CAI.

Studies conducted in the literature determined that growth in wound culture was a risk factor in CAI formation [32]. Our study decided that growth in wound culture was a risk factor for CAI development ($p < 0.0001$).

The basic principles of surgery (good surgical technique, asepsis and antisepsis applications) should be followed to prevent perioperative infections in surgery. In our study, a significant increase in the risk of CAI development was observed in patients with incision lengths exceeding 13 cm ($p = 0.027$). Still, no significant difference was observed between the groups after 14 cm (4 - 13 cm, 14 - 23 cm, 24 - 32 cm, 33 - 42 cm, 43 - 52 cm).

It was determined that blood transfusion was widely applied in surgery and used as a lifesaver. Hemodynamically stable patients in the postoperative period generally tolerate haemoglobin values > 7 g/dl well [38]. According to the data obtained in the literature, blood transfusion should be avoided as much as possible. In the meta-analysis conducted by Hill *et al.* [39], it was determined that there was a three-fold increase in the rate of nosocomial infection [36] after blood transfusion. Our study observed significantly more surgical site infections in patients who received blood transfusions. Due to univariate analysis, blood transfusion was accepted as an independent risk factor for surgical site infections.

5. Conclusions and Recommendations

CAI is one of the most common complications in hospitals and one of the most costly infections. Although correcting all patient risk factors is impossible, al-most all risk factors related to the surgical process can be fixed. For this reason, it has been determined that knowing the risk factors that cause CAI and implementing preventive interventions reduce the incidence of these infections.

When the literature is analysed, definite risk factors in the development of CAI have been revealed in the studies conducted so far. These risk factors are grouped as patient-related risk factors associated with the operative process. In our study, gender, diabetes mellitus and malignancy were found to be associated with increased rates of CAI. Among the risk factors related to the operative process, the degree of contamination, ASA score ≥ 3, preoperative skin cleansing, duration of intensive care unit stay, duration of hospitalisation, growth in wound culture, duration of surgery and incision length were determined as risk factors that increased CAI rates. The degree of contamination, duration of intensive care unit stay, duration of operation, growth in wound culture, and duration of hospitalisation were determined as solid factors in the development of CAI.

As a result of these data, intervention to modifiable and predictable factors can be evaluated to prevent the development of CAI. Therefore, studies assessing risk factors and studies with a more significant number of patients are needed. As a result of our research, it was determined that keeping the blood glucose level of the patients at an average level with close monitoring and intervention would be effective in reducing wound site infections. The development of CAI can be prevented by better wound care and prevention of contamination. Careful preoperative skin cleansing is seen as a factor in reducing the occurrence of CAI. To cope with CAI, institutional behaviour, compliance with guidelines and taking measures to prevent CAI should be given importance.

Information note about Ethics Committee Approval

Ethics Committee Name and Approval was obtained from Dokuz Eylül University Faculty of Medicine Izmir/Turkey, but records before 2011 could not be accessed. Ethical Approval has not been received from any external committee.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Belek, H.A. (2022) Hospital Infection in Terms of Medical Law. *Istanbul Medipol University Journal of Faculty of Law*, **9**, 1-27.

[2] Özer, S. and Ay, A. (2022) Infection Control in Coronary Intensive Care Units: What Should I Know? *Turkish Journal of Cardiovascular Nursing*, **13**, 125-129. https://doi.org/10.5543/khd.2022.214380

[3] Mireya, U.A., Marti, P.O., Xavier, K.V., Cristina, L.O., Miguel, M.M. and Magda, C.M. (2007) Nosocomial Infections in Pediatric and Neonatal Intensive Care Units. *Journal of Infection*, **54**, 212-220. https://doi.org/10.1016/j.jinf.2006.03.023

[4] Çelik, R. and Özel, F. (2020) Comparison of Development Rates of Nosocomial Infections in Intensive Care Units in Turkey. *Health Academy Kastamonu* (*SAK*), **5**, 158-169. https://doi.org/10.25279/sak.335045

[5] Dağlı, Ö., Tosun, F. and Kılıç, A. (2020) Evaluation of Surgical Site Infections and Analysis of Risk Factors. *ANKEM Journal*, **34**, 91-98. https://doi.org/10.5222/ankem.2020.091

[6] Lin, S., Melki, S., Lisgaris, M.V., Ahazizadeh, E.N. and Zender, C.A. (2017) Post-operative MRSA Infections in Head and Neck Surgery. *American Journal of Otolaryngology-Head and Neck Medicine and Surgery*, **38**, 417-421. https://doi.org/10.1016/j.amjoto.2017.03.013

[7] Stone, P.W., Braccia, D. and Larson, E. (2005) Systematic Review of Economic Analyses of Health Care-Associated Infections. *American Journal of Infection Control*, **33**, 501-509. https://doi.org/10.1016/j.ajic.2005.04.246

[8] Fry, D.E. (2011) Fifty Ways to Cause Surgical Site Infections. *Surgical Infections* (*Larchmt*), **12**, 497-500. https://doi.org/10.1089/sur.2011.091

[9] Anderson, D.J., Kirkland, K.B. and Auten, G. (2007) Underresourced Hospital Infection Control and Prevention Programs: Penny Wise, Pound Foolish? *Infection Control & Hospital Epidemiology*, **28**, 767-773. https://doi.org/10.1086/518518

[10] Cullen, K.A., Hall, M.J. and Golosinskiy, A. (2009) Ambulatory Surgery in the United States. *National Health Statistics Reports*, **28**, 1-25.

[11] Tanner, J., Padley, W., Assadian, O., Leaper, D., Kiernan, M. and Edmiston, C. (2015) Do Surgical Care Bundles Reduce the Risk of Surgical Site Infections in Patients under Going Colorectal Surgery? A Systematic Review and Cohort Meta-Analysis of 8,515 Patients. *Surgery*, **158**, 66-77. https://doi.org/10.1016/j.surg.2015.03.009

[12] Ulu, A.C. (2016) Surgical Site Infections. *Türkiye Klinikleri Journal of Infectious Diseases Special Topics*, **9**, 22-29.

[13] Korol, E., Johnston, K., Waser, N., Sifakis, F., Jafri, H.S., Lo, M. and Kyaw, M.H. (2013) A Systematic Review of Risk Factors Associated with Surgical Site Infections among Surgical Patients. *PLOS ONE*, **8**, e83743. https://doi.org/10.1371/journal.pone.0083743

[14] Ateş, S., Nazik, S., Şahin, A.R., Kardaş, F. and Erdoğan, A. (2019) Evaluation of Surgical Site Infections. *Journal of Kahramanmaraş Sütçü Imam University Faculty of Medicine*, **14**, 16-19. https://doi.org/10.17517/ksutfd.467381

[15] Marul, F. and Aygin, D. (2016) Innovations in the Definitions of Surgical Site Infection and Current Practices in Preoperative Feather Cleaning. *Online Turkish Journal of Health Sciences*, **1**, 28-36.

[16] Uzunkoy, A. (2005) Surgical Site Infections: Risk Factors and Methods of Prevention. *National Journal of Trauma and Emergency Surgery*, **11**, 269-282.

[17] Aşık, G., Özoğuz, P., Tünay, H., Bulut, A., Kaçar, S.D. and Bal, A. (2014) Commonly Isolated Microorganisms from Wounds with Their Antibiotic Resistance Patterns. *Surgical Arts Journal*, **7**, 18-22.

[18] Shree, R., Park, S.Y., Beigi, R.H., Dunn, S.L. and Krans, E.E. (2016) Surgical Site Infection Following Cesarean Delivery: Patient, Provider and Procedure Specific Risk Factors. *American Journal of Perinatology*, **33**, 157-164. https://doi.org/10.1055/s-0035-1563548

[19] Kalkan, N. and Karadağ, M. (2017) Current Approaches to Prevent Surgical Site Infections and Prevention Interventions Algorithm for Nurses. *Gümüşhane Universi-*

ty Journal of Health Sciences, **6**, 280-289.

[20] BerrÍOs-Torres, S.I., Umscheid, C.A., Bratzler, D.W., Leas, B., Stone, E.C., Kelz, R.R., *et al.* (2017) Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection. *JAMA Surgery*, **152**, 784-791. https://doi.org/10.1001/jamasurg.2017.0904

[21] Lin, F., Gillespie, B.M., Chaboyer, W., Li, Y., Whitelock, K. and Morley, N. (2019) Preventing Surgical Site Infections: Facilitators and Barriers to Nurses' Adherence to Clinical Practice Guidelines—A Qualitative Study. *Journal of Clinical Nursing*, **28**, 1643-1652. https://doi.org/10.1111/jocn.14766

[22] Qvistgaard, M., Lovebo, J. and Almerud-Österberg, S. (2019) Intraoperative Prevention of Surgical Site Infections as Experienced by Operating Room Nurses. *International Journal of Qualitative Studies on Health and Well-Being*, **14**, Article ID: 1632109. https://doi.org/10.1080/17482631.2019.1632109

[23] Gezginci, E. and Göktaş, S. (2023) Prevention of Surgical Site Infection. In: Gürkan, A., Ed., *Care Sensitive Quality Indicators in Surgical Nursing*, Turkey Clinics, Ankara, 13-19.

[24] Elay, G., Ulu Kılıç, A. and Alp, E. (2016) Approach to Common Infections in Intensive Care Units: Diagnosis, Treatment and Infection Control Measures Erciyes University. Health Application and Research Center, Kayseri, 64-66.

[25] Yılmaz, G.R., Bayazıt, N.F. and Erdinç, S. (2014) Surgical Site Infections (SSI). *Flora*, **19**, 28-36.

[26] Prospero, E., Cavicchi, A., Bacelli, S., *et al.* (2006) Surveillance for Surgical Site Infection after Hospital Discharge: A Surgical Procedure-Specific Perspective. *Infection Control & Hospital Epidemiology*, **27**, 1313-1317. https://doi.org/10.1086/509838

[27] Dumville, J.C., McFarlane, E., Edwards, P., Lipp, A., Holmes, A. and Liu, Z. (2015) Preoperative Skin Antiseptics for Preventing Surgical Wound Infections after Clean Surgery. *Cochrane Database of Systematic Reviews*, No. 3, CD003949. https://doi.org/10.1002/14651858.CD003949.pub4

[28] Balkan, A. and Çelebi, C. (2020) Cerrahi Alan İnfeksiyonları. *Black Sea Journal of Health Science*, **3**, 46-50.

[29] Watanabe, A., Kohnoe, S., Shımabukuro, R., Yamanaka, T., Iso, Y., Baba, H., Higashi, H., Orita, H., Emi, Y., Takahashi, I., Korenaga, D. and Maehara, Y. (2008) Risk Factors Associated with Surgical Site Infection in Upper and Lower Gastrointestinal Surgery. *Surgery Today*, **38**, 404-412. https://doi.org/10.1007/s00595-007-3637-y

[30] Topaloğlu, S., Akın, M., Avşar, F.M., Özel, H., Polat, E. Akın, T., Karabulut, E. and Hengirmen, S. (2008) Correlation of Risk and Postoperative Assessment Methods in Wound Surveillance. *Journal of Surgical Research*, **146**, 211-217. https://doi.org/10.1016/j.jss.2007.05.016

[31] Reid, R., Simcock, J.W. and Chisholm, L. (2002) Postdischarge Clean Wound Infections: Incidence Underestimated and Risk Factors Overemphasized. *ANZ Journal of Surgery*, **72**, 339-343. https://doi.org/10.1046/j.1445-2197.2002.02403.x

[32] Janet, K., Bundy, R.N., Virginia, R., Gonzalez, B.S., Bonnie, M., *et al.* (2006) Gender Risk Differences for Surgical Site Infections among a Primary Coronary Artery Bypass Graft Surgery Cohort: 1995-1998. *American Journal of Infection Control*, **34**, 114-121. https://doi.org/10.1016/j.ajic.2005.10.003

[33] Sangrasi, A.K., Leghari, A.A., Memon, A., Talpur, A.K., Qureshi, G.A. and Memon, J.M. (2008) Surgical Site Infection Rate and Associated Risk Factors in Elective General Surgery at a Public Sector Medical University in Pakistan. *International*

Wound Journal, **5**, 74-78. https://doi.org/10.1111/j.1742-481X.2007.00365.x

[34] Malone, D.L., *et al.* (2002) Surgical Site Infections: Reanalysis of Risk Factors. *Journal of Surgical Research*, **103**, 89-95. https://doi.org/10.1006/jsre.2001.6343

[35] Fiorio, M., Marvaso, A., ViganÒ, F. and Marchetti, F. (2006) Incidence of Surgical Site Infections in General Surgery in Italy. *Infection*, **34**, 310-314. https://doi.org/10.1007/s15010-006-6632-0

[36] Delgado-Rodriguez, M., Mariscal-Ortiz, M., Gomez-Ortega, A., Martinez-Gallego, G., Palma-Perez, S., Sillero-Arenas, M. and Medina-Cuadros, M. (2003) Alcohol Consumption and the Risk of Nosocomial Infection in General Surgery. *British Journal of Surgery*, **90**, 1287-1293. https://doi.org/10.1002/bjs.4186

[37] Muilwijk, J., Hof, S.V. and Jan, C.W. (2007) Associations between Surgical Site Infection Risk and Hospital Operation Volume and Surgeon Operation Volume among Hospitals in the Dutch Nosocomial Infection Surveillance Network. *Infection Control and Hospital Epidemiology*, **28**, 557-563. https://doi.org/10.1086/513613

[38] Hebert, P.C., Wells, G., Blajchman, M.A., *et al.* (1999) A Multi-Center, Randomized, Controlled Clinical Trial of Transfusion Requirements in Critical Care. *The New England Journal of Medicine*, **340**, 409-417. https://doi.org/10.1056/NEJM199902113400601

[39] Hill, G.E., Frawley, W.H., Griffith, K.E., *et al.* (2003) Allogeneic Blood Transfusion Increases the Risk of Postoperative Bacterial Infection: A Meta-Analysis. *The Journal of Trauma*, **54**, 908-914. https://doi.org/10.1097/01.TA.0000022460.21283.53