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A detailed analysis of surgical site infections and risk factors: A multicentric cohort study in Türkiye

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Abstract

There is limited data on surgical site infection (SSI) in developing countries. The aim of this study was to investigate the incidence and risk factors of SSI following general surgical operations in Türkiye. This multicenter cohort study was conducted at 10 centers. Patients who underwent thyroid/parathyroid, breast, hernia and abdominal surgery between September 2017 and March 2018 were included in the study. Center for Disease Control and Prevention 2016 (CDC-2016) criteria was used for the diagnosis of SSI. Patients were followed for 30 days (90 days for mesh patients). Out of 1871 patients included, SSI occurred in 181 (9.7%) patients. Of these SSI, 101 (55.8%) were superficial, 41 (22.7%) deep, and 39 (21.5%) organ/space SSI. SSI incidence was seen to be high (>15.0%) following some surgeries (40.0% in pancreas, 39.1% in biliary duct, 30.3% in small bowel, 27.9% in colorectal, 27.3% in esophagus, 24.1% in liver, 15.7% in gastric). SSI incidences were generally <5.0% after some surgeries (4.4% in hernia, 4.2% in gallbladder, 3.3% in morbid obesity, 1.4% in breast, 0.8% in thyroid/parathyroid, and zero in spleen and surrenal). In univariate analysis, age ≥60 years, female sex, preoperative weight loss, presence of comorbidities, preoperative albumin <3.5 g/dL and hemoglobin <12 g/dL, wound classification, ASA score, general anesthesia, emergency surgery, open surgery, operation time ≥4 hours, intraoperative blood loss ≥400 ml, perioperative blood transfusion, drain placement, distant infection and malignant disease were associated with SSI. In multivariate analysis preoperative weight loss, clean-contaminated wound, general anesthesia, emergency surgery, open surgical technique, prolonged operation duration (≥4 hours), drain placement, and distant infection were found to be independent variable for SSI risk. In order to reduce the incidence of SSI, patients with a weight loss of 10% or more in six months preoperatively should be identified, and nutritional status of the patients should be corrected preoperatively, laparoscopic technique should be preferred in abdominal surgeries, and drain placement should be avoided, especially in clean-contaminated wounds.

Keywords: wound infection, obesity, colorectal, hepatopancreatobiliary, gastrectomy, appendectomy

1. Introduction

The Center for Disease Control and Prevention (CDC) defines surgical site infection (SSI) as an infection that occurs at the surgical site within 30 days after surgery (90 days if prosthetic material was implanted) (1). SSIs are deemed the most common problematic event threatening patients' safety worldwide (1). SSIs are considered the most common form of nosocomial infection among surgical patients (2). SSIs are serious complications that result in increased morbidity,

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hospital costs, prolonged hospital stay, and mortality (2). A lot of risk factors have been associated with SSI, including patient-related characteristics (e.g. age, poor nutritional status, and severe comorbid conditions) and surgery-related characteristics (e.g. long duration of operation, wound classification, and absence of antibiotic prophylaxis) (2). In patients with SSI risk factors, clinicians can implement appropriate prevention strategies and effective measures to diagnose infection and initiate therapy at an early stage (2). SSI and SSI incidence are evaluated as indicators of the quality of surgical care (3). There is limited data on SSI and SSI incidence in developing countries such as in our country (4). The aim of this study was to investigate SSI incidence and risk factors following general surgical procedures in Türkiye.

2. Materials and Methods

2.1. Definition of the population

This prospective cohort study was approved by the Malatya Clinical Research Ethics Committee (Incidence of surgical site infection and causative factors-2017/118) and it was carried out between September 2017 and March 2018 in 10 centers. One of the centers participating in the study was a secondary state hospital, and the others were tertiary training and research hospital. Two hundred and seventy patients from the secondary state hospital and 15, 236, 375, 24, 155, 268, 222, 54 and 252 patients from the tertiary training and research hospitals, respectively, were included in the study. Patients who underwent thyroid/parathyroid, breast, hernia (groin, abdominal wall, and intra-abdominal), and abdominal surgeries (hepatopancreatobiliary (liver, gallbladder, pancreas, and biliary duct), gastric, small bowel, colorectal, appendix, morbid obesity, spleen, and surrenal gland) were included in the study; whereas, those who underwent anal fissure, perianal fistula, hemorrhoid, pilonidal sinus, and benign soft tissue tumor were excluded from the study. In addition, patients who died within the early postoperative period (within 24 hours), those whose incisions were closed with an open abdomen, and those younger than 18 years of age were excluded from the study. Informed consent was obtained for the study.

2.2. Diagnosis of SSI

SSI was diagnosed by the attending physician and confirmed by infectious disease physicians. The diagnosis was done using the CDC-2016 criteria (1). SSIs were classified according to the CDC classification as follows: (1) superficial incisional involving only the skin or subcutaneous tissue of the incision; (2) deep incisional involving the fascia and/or muscular layers of the incision, and (3) organ-space involving any part of the body opened or manipulated during the procedure excluding the skin incision, fascia, or muscle layers. The diagnosis of incisional SSI was performed based on purulent discharge and/or bacteriological culture from a surgical incision. Organ/cavity SSI was defined as a positive culture from fluid collection or fluid collection detected by imaging findings in a patient with fever, abdominal pain, and postoperative ileus. In the presence of more than one SSI type, the more complex SSI type was recorded. The follow-up period for the diagnosis of SSI was set as 30 days (90 days for patients who had mesh) after surgery, and the follow-up was conducted when the patient was in the clinic or during readmission to the outpatient clinic.

The participating centers were informed about infection control measures, diagnosis of SSI, surgical wound classification, and appropriate antibiotic administration in accordance with current guidelines (reference 1, 5-7) before the study. The study was initiated after counseling. These precautions are as follows: Surgical Wound Classification was defined according to international guidelines as follows (1-5): clean, clean-contaminated, contaminated, and dirty wound. Antibioprophylaxis was given according to the wound classification as follows: Antibioprophylaxis was given 30 to 60 minutes before the surgery procedure. An additional dose was administered when the operating time was longer than four hours and when the intraoperative hemorrhage was ≥1500 ml. Antibioprophylaxis was continued for 24 hours in clean (with mesh), clean-contaminated, and contaminated wounds. Surgeons selected the prophylactic antibiotic agent based on the experience of their centers. The appropriate of antibioprophylaxis was evaluated according to international guidelines (1, 5-7). Drains were used or not used according to the surgeon's preference.

Age, sex, body mass index (BMI), smoking status, comorbidities, wound classification, antibioprophylaxis, American Society of Anesthesiologists (ASA) score, anesthesia type, operation timing, operation technique, operation duration, intraoperative blood loss, perioperative blood transfusion, drain placement, distant infection, SSI, culture, duration of hospital stay, and mortality were recorded via a Google forms database.

2.3. Statistical analysis

SPSS 22 (IBM Corp., Chicago, IL, USA) was used for statistical analysis. Shapiro–Wilk test was used to test normality in statistical calculations. Chi-square, Fisher chi-square, Student t, and Mann-Whitney U tests were used for categorical and continuous variables when appropriate. In the analysis of categorical and continuous data, univariate and multivariate logistic regression analysis was performed for variables, and a p-value of < 0.05 was considered statistically significant in all analyses.

3. Results

A total of 2042 patients underwent surgery during the study period. We excluded sixty-nine patients who underwent anal fissure, perianal fistula, and hemorrhoid surgeries, 58 who underwent pilonidal sinus surgery, 41 who underwent benign soft tissue tumor surgery, and 3 patients who died in the early postoperative period. Finally, a total of 1871 patients were included in the study. While SSI was seen in 181 patients, SSI was not seen in 1690 patients. Table 1 summarizes the patient groups and SSI rates.

Table 1. Patients groups and surgical site infection rates included in the study

Parameters	Total	Surgical site infection (+)	Surgical site infection (-)
Gastrointestinal (n, %)	478 (25.5)	105 (22.0)	373 (78.0)
Esophagus	11	3 (27.3)	8 (72.7)
Gastric	102	16 (15.7)	86 (84.3)
Small bowel	66	20 (30.3)	46 (69.7)
Appendix	134	20 (14.9)	114 (85.1)
Colon-rectum	165	46 (27.9)	119 (72.1)
Hepatopancreatobiliary (n, %)	520 (27.8)	53 (10.2)	467 (89.8)
Gallbladder	408	17 (4.2)	391 (95.8)
Liver	54	13 (24.1)	41 (75.9)
Pancreas	35	14 (40.0)	21 (60.0)
Biliary duct	23	9 (39.1)	14 (60.9)
Hernia (n, %)	343 (18.3)	15 (4.4)	328 (95.6)
With mesh	314	14 (4.5)	300 (95.5)
Inguinal	192	0 (0)	192 (100.0)
Abdominal Wall	118	14 (11.9)	104 (88.1)
Intraabdominal	4	0 (0)	4 (100.0)
Without mesh	29	1 (3.4)	28 (96.6)
Inguinal	18	1 (5.3)	17 (94.7)
Abdominal Wall	9	0 (0)	9 (100.0)
Intraabdominal	2	0 (0)	2 (100.0)
Morbid obesity (n, %)	121 (6.5)	4 (3.3)	117 (96.7)
Breast (n, %)	144 (7.7)	2 (1.4)	142 (98.4)
Thyroid-Parathyroid (n, %)	241 (12.9)	2 (0.8)	239 (99.2)
Spleen (n, %)	19 (1.0)	0 (0)	19 (100.0)
Surrenal (n, %)	5 (0.3)	0 (0)	5 (100.0)
Total (n, %)	1871	181 (9.7)	1690 (90.3)

The median patient age was 51 (18–98), and 819 (43.8%) of the patients were male. BMI of the patients was 27.1. While the ASA score was ASA-I in 524 patients, ASA-II in 995 patients, ASA-III in 269 patients, and ASA-IV in 18 patients, the ASA score of 65 patients was unknown. Regarding wound classification, the wounds of 747 patients were classified as clean, 1054 as clean-contaminated, 35 as contaminated, and 35 as dirty. Antibiotic prophylaxis was used in 1439 (76.9%) patients. In our study, cefazolin was administered to 922 (49.3%), ceftriaxone to 431 (23.0%), and ampicillin-sulbactam to 86 (4.6%) patients, while antibioprophylaxis was not given to 397 (21.2%) patients. Antibiotic treatment was used in 35 patients (1.9%) in the dirty wound classification. Regarding the type of anesthesia, 1644 (87.9%) patients were operated under general anesthesia and 227 (12.1%) under regional anesthesia. Elective surgery was performed in 1497 (80.0%) patients and emergency surgery in 374 (20.0%) patients. A total of 857 (65.9%) open surgeries and 598 (32.0%) laparoscopic surgeries were performed in patients who underwent abdominal surgery. The surgical procedure could not be completed laparoscopically in 31 (2.1%) patients. Median operation duration was 60 minutes (10–840). SSI was diagnosed in 181 (9.7%) patients. Of these SSIs, 101 (55.8%) were superficial, 41 (22.7%) deep, and 39 (21.5%) were organ/space SSIs. Distant infections were seen in 58 (3.1%) patients. The most common distant infections were pneumonia (75.9%) and urine tract infection (32.8%). The median hospital stay was 3.3 (1-79) days. Mortality developed in 29 patients. (Table 2).

Pathogenic microorganisms were isolated in the culture of 96 patients (Table 3). More than one pathogenic microorganism was isolated in the culture of 25 patients. The most isolated pathogenic microorganism type was gram negative bacilli (65.2%). The most frequently isolated pathogenic microorganisms were Escherichia coli (38.0%) and Enterococcus species (20.7%).

In univariate analysis, age ≥60 years (OR: 2.147, $p < 0.001$); female patients (OR: 1.511, $p = 0.008$); presence of comorbidity (OR: 2.078, $p < 0.001$); preoperative weight loss (OR: 4.391, $p < 0.001$), preoperative albumin level <3.5 gr/dL (OR: 2.340, $p < 0.001$); preoperative hemoglobin level <12 gr/dL (OR: 2.637, $p < 0.001$); wound classification (OR: 0.146 for clean class, OR: 2.712 for clean-contaminated class, OR: 5.146 for contaminated class, OR: 5.867 for dirty class; $p < 0.001$ for all); ASA III and IV scores (OR: 3.035, $p < 0.001$); general anesthesia (OR: 13.746, $p < 0.001$), emergency surgery (OR: 3.444, $p < 0.001$); open surgical technique (OR: 9.379, $p < 0.001$); operation duration ≥4 hours ((OR: 7.079, $p < 0.001$); intraoperative blood loss ≥400 ml (OR: 6.994, $p < 0.001$); periperative blood transfusion (OR: 4.631, $p < 0.001$); drain placement (OR: 3.767, $p < 0.001$); distant infection (OR: 14.850, $p < 0.001$); and malignant pathology (OR: 2.031, $p < 0.001$ were found to be risk factors of SSI. In multivariate analysis, preoperative weight loss (OR: 1.610, $p = 0.04$); clean-contaminated wound classification (OR: 4.104, $p = 0.02$); general anesthesia (OR: 6.440, $p = 0.02$); emergency surgery (OR: 2.231, $p = 0.003$), open surgical technique (OR: 17.857, $p < 0.001$); operation duration ≥4 hours (OR: 10.148, $p < 0.001$); drain placement (OR: 3.212, $p < 0.001$); and distant infection (OR: 6.250, $p < 0.001$) were found to be independent variable for SSI risk (Table 4).

Table 2. Patient demographics

Parameters	Total
Age (years, median (min-max))	51 (18-98)
Gender (n, %)	
Male	819 (43.8)
Female	1052 (56.2)
Body massindex (kg/m^2,median (min-max))	27.1 (14.7-60.4)
Preoperativeweightloss	
Yes	172(9.2)
No	1689(91.8)
ASA score (n, %)	
I	524 (28.0)
II	995 (53.2)
III	269 (14.4)
IV	18 (1.0)
na	65 (3.5)
Woundclassification (n, %)	
Clean	747 (39.9)
Clean-contamined	1054 (56.3)
Contamined	35 (1.9)
Dirty	35 (1.9)
Antibioticprophylaxis (n, %)	
Cleanwound	467(25.0)
Cefazolin	420
Ceftriaxone	10
Ampicillin-sulbactam	37
Clean-contaminatedwound	940(50.2)
Cefazolin	491
Ceftriaxone	402
Ampicillin-sulbactam	47
Contaminatedwound	32(1.7)
Cefazolin	11
Ceftriaxone	19
Ampicillin-sulbactam	2
No-antibioticprophylaxis	432 (23.1)
Anesthesiatype (n, %)	
General	1644 (87.9)
Regional	227 (12.1)
Operationtiming (n, %)	
Elective	1497 (80.0)
Emergency	374 (20.0)
Operationduration (minute, median (min-max))	60 (10-840)
SSI (n, %)	
Superficial	101 (55.8)
Deep	41 (22.7)
Organ/space	39 (21.5)
Distantinfection (n, %)	58(3.1)
Pneumonia	44 (2.4)
Urinetractinfection	19 (1.0)
Encephalitis	1 (0)
Cellulite	1 (0)
Lenght of hospitalstay (day, median (min-max))	3.3 (1-79)
Mortality (n)	29 (1.6)

ASA: AmericanSociety of Anesthesiologist, **SSI:** Surgical site infection

4. Discussion

This study is the first multicenter study for SSI conducted by general surgeons in Türkiye. In this study, we found that the SSI incidence was 9.7%. SSI incidence following general surgery operations in the world varies between 4.1% and 26.7%, depending on the type of surgery and patient-related factors (8). The incidence of SSI following general surgery operations in Türkiye varies between 8.8 and 15.2% (9-10). Many risk factors (e.g., age, comorbidity, nutritional status, obesity, history of malignancy, gender, wound classification, perioperative blood transfusion, surgical technique, drain, etc.) have been reported for SSI in previous studies (8-11). In our multicentric study, we found that preoperative weight loss, clean-contaminated wound, general anesthesia, emergency surgery, open surgical technique, prolonged operation duration (≥4 hours), drain placement, and distant infection were independent variables for SSI risk.

Preoperative weight loss is defined as unintentional weight loss >10% of the baseline body weight in the last six months before surgery. Especially preoperative unintentional weight loss in patients undergoing gastrointestinal surgery is associated with increased morbidity such as SSI (12). A study in patients who had colorectal surgery found that preoperative weight loss increased the incidence of deep and organ/space SSIs (12). Our data support that preoperative weight loss increases the risk of SSI in patients. Multivariate analysis of our data found that preoperative unintentional weight loss increased the incidence of SSI 1.6-fold (p=0.04). We attributed this to the high number of patients who underwent gastrointestinal surgery in our study and the high preoperative involuntary weight loss in these patients (155/1142, 13.6%). Therefore, it is important to recognize these patients before the operation.

Perioperative anesthetic type affects the risk of SSI. Regional anesthesia (spinal or epidural) increases tissue perfusion and oxygenation due to the sympathetic blocking effect (13); therefore, SSI incidence is lower in regional anesthesia compared to general anesthesia (13,14). Studies have shown that the incidence of SSI in cesarean section, hip or knee surgery performed with regional anesthesia is found to be lower than those performed with general anesthesia (13-15). In our study, we found that the SSI incidence was lower in patients who had regional anesthesia (p = 0.02). However, this result cannot change the risk factor for our study. In our study, regional anesthesia was mostly applied to patients with a low incidence of SSI, such as hernia (343 patients), while general anesthesia was applied to patients with a high incidence of SSI, such as gastrointestinal surgery (1142 patients).

Wound class is often used to estimate a patient's risk for postoperative surgical site infection (SSI) (16). A wound classification system is a major estimator of SSI (17), and antibioprophylaxis is performed according to wound classification (6,7). SSI incidence is 1%–5% in clean wounds, 3%–11% in clean/contaminated wounds, 10%–17% in contaminated wounds, and >27% in dirty wounds (18,19). In our study, SSI incidence was found to be 2.4% in clean wounds, 13.1% in clean/contaminated wounds, 34.3% in contaminated wounds, and 37.1% in dirty wounds. In our study, although SSI incidence increased 4.1 times in clean-contaminated wounds, 1.5 times in contaminated, and 1.5 times in dirty wounds, only clean-contaminated wound was found to be an independent variable for SSI risk (p = 0.02). Appropriate surgical antimicrobial prophylaxis (SAP), which is an integral part of surgical site infection SSI prevention, is one of the major preventable risks to surgical patient safety (20). Kaya et al. reported that the rate of inappropriate antibioprophylaxis was 27.1% and was a risk factor for SSI (9). However, inappropriate antibioprophylaxis did not significantly affect the SSI incidence in our study (Table 4).

Table 3. Pathogen microorganisms isolated from culture

Microorganisms	n (%)	HPB	Colorectal	Upper GIS	Bariatric surgery	Hernia	Breast	Throid Parathyroid	Small bowel	Appendix
Gram negative bacilli (n)										
Escherichia coli	46 (38.0)	10	10	9	6	5	3	1	1	1
Klebsiella spp	9 (7.4)	3	2	1	1	0	1	1	0	0
Pseudomonas	7 (5.8)	4	2	0	0	0	0	0	0	1
aeroginosa	6 (5.0)	3	1	2	0	0	0	0	0	0
Acinetobacter	5 (4.1)	2	2	1	0	0	0	0	0	0
baumannii	4 (3.3)	2	1	0	0	0	1	0	0	0
Enterobacter spp	1 (0.8)	1	0	0	0	0	0	0	0	0
Morganella morganii	1 (0.8)	0	0	0	1	0	0	0	0	0
Proteus vulgaris	79 (65.2)	25	18	13	8	5	5	2	1	2
Citrobacter spp										
Total										
Gram pozitive coccus (n)										
Enterococcus spp	25 (20.7)	8	4	4	2	1	1	3	1	1
Stafilococcus aureus	7 (5.8)	2	0	0	1	2	1	1	0	0
Streptococcus spp	3 (2.5)	2	0	0	0	0	0	0	1	0
Gram positive coccus	1 (0.8)	0	0	0	1	0	0	0	0	0
Total	36 (29.8)	12	4	4	4	3	2	4	2	1
Fungal (n)										
Candida albicans	6 (5.0)	4	2	0	0	0	0	0	0	0
Total (n)	121 (100.0)	41	24	17	12	8	7	6	3	3

Upper GIS: Gastric, esophagus **HPB:** Hepatopancreatobiliary (Liver, gallbladder, bile duct, pancreas) **Klebsiella spp:** Klebsiella pneumonia, Klebsiella oxytoca **Klebsiella spp:** Klebsiella pneumonia, K.Oxytoca **Enterobacter spp:** Enterobacter aerogenes, Enterobacter cloacae, Enterobacter casseliflavus **Citrobacter spp:** Citrobacter freundii, Citrobacter sedlakii **Enterococcus spp:** Enterococcus faecalis, Enterococcus faecaliscus, Enterococcus faecium **Streptococcus spp:** Streptococcus agalactiae, Streptococcus sciuri, Streptococcus anginosus

Table 4. Patient demographics univariate and multivariate analysis

Parameters	SSI (+) n=181	SSI (-) n=1690	Univariate analysis				Multivariate analysis			
				%95 C.I.				%95 C.I.		
	n (%)	n (%)	OR	Lower	Upper	P	OR	Lower	Upper	P
Age (years)										
<60	100 (7.5)	1227				<0.001				
≥60	81 (14.9)	(92.5)	2.147	1.571	2.932					
		463 (85.1)								
Gender										
Female	96 (11.7)	723 (88.3)	1.511	1.111	2.054	0.008				
Male	85 (8.1)	967 (91.9)								
BMI (kg/m^2)										
<30	122 (9.7)	1130				0.88				
≥30	59 (9.5)	(90.3)								
		560 (90.5)								
Smoking										
Ex or current smoker	68 (10.3)	591 (89.7)				0.31				
Never smoked	86 (8.8)	890 (91.2)								
na	27 (9.4)	208 (90.6)								
Preoperative weight loss (>10% in 6 months before surgery)										
Yes	47 (27.3)	125 (72.7)	4.391	3.006	6.415	<0.001	1.610	1.022	3.035	0.04
No	134 (7.9)	1565								
		(92.1)								
Comorbidity										
Yes	97 (13.6)	616 (86.4)	2.078	1.514	2.852					
No	76 (7.0)	1003				<0.001				
na	8 (9.7)	(93.0)								
		71 (90.3)								
Preoperative albumin (gr/dL)										
<3.5	96 (15.4)	527 (84.6)	2.340	1.715	3.193					
≥3.5	84 (7.2)	1079				<0.001				
na	1 (1.2)	(92.8)								
		84 (98.8)								

Preoperative hemoglobin (gr/dL)										
<12	67 (17.9)	308 (82.1)	2.637	1.903	3.654	<0.001				
≥12	114 (7.6)	1382 (92.4)								
Wound classsification										
Clean	18 (2.4)	729 (97.6)	0.146	0.089	0.239	<0.001				0.04
Clean-contamined	138 (13.1)	916 (86.9)	2.712	1..901	3.869	<0.001	4.104	1.292	13.036	0.02
Contamined	12 (34.3)	23 (65.7)	5.146	2.516	10.527	<0.001	1.488	0.576	3.841	0.41
Dirty	13 (37.1)	22 (62.9)	5.867	2.902	11.859	<0.001	1.468	0.457	4.714	0.52
ASA score										
I-II	117 (7.7)	1402 (92.3)								
III-IV	58 (20.2)	229 (79.8)	3.035	2.151	4.283	<0.001				
na	6 (9.2)	59 (90.8)								
Anesthesia type										
General	179 (10.9)	1465 (89.1)	13.746	3.387	55.779	<0.001	6.440	1.419	29.222	0.02
Regional	2 (0.9)	225 (99.1)								
Appropriate antibiotic prophylaxis (Yes)										
Clean wound	15 (3.2)	452 (96.8)				0.78				
Clean-contaminated wound	108 (11.5)	832 (88.5)				0.23				
Contaminated wound	11 (34.4)	21 (65.6)				1.00				
Total	134 (9.3)	1305 (90.7)				0.76				
Operation timing										
Emergency	77 (20.5)	297 (79.5)	3.444	2.501	4.744	<0.001	2.231	1.307	3.806	0.003
Elective	104 (7.0)	1393 (93.0)								
Operation technique										
Open	163 (18.4)	725 (81.6)	9.379	5.375	16.363	<0.001	17.857	8.653	36.850	<0.001
Laparoscopy	14 (2.3)	584 (97.7)								
Operation duration (hours)										
<4	143 (8.1)	1625 (91.9)								
≥4	38 (38.4)	61 (61.6)	7.079	4.561	10.998	<0.001	10.148	5.260	19.576	<0.001
na	0	4 (100.0)								
The use of mesh										
Yes	14 (4.5)	300 (95.5)				1.00				
No	1 (3.4)	28 (96.6)								
İntraoperative blood loss (ml)										
<400	155 (8.7)	1626 (91.3)								
≥400	18 (40.0)	27 (60.0)	6.994	3.767	12.984	<0.001				
na	8 (17.8)	37 (82.2)								
Perioperative blood transfusion										
Yes	17(31.5)	37 (68.5)	4.631	2.551	8.407	<0.001	0.482	0.222	1.044	0.06
No	164 (9.0)	1653 (91.0)								
Drain placement										
Yes	161 (12.7)	1109 (87.3)	3.767	2.385	5.949	<0.001	3.212	1.699	6.070	<0.001
No	20 (3.3)	581 (96.7)								
Distant infection										
Yes	33 (56.9)	25 (43.1)	14.850	8.600	25.641	<0.001	6.250	3.180	12.285	<0.001
No	148 (8.2)	1665 (91.8)								
Pathology										
Malignant	62 (15.2)	345 (84.8)	2.031	1.462	2.822	<0.001	0.583	0.336	1.009	0.054
Benign	119 (8.1)	1345 (91.9)								
Mortality										
Yes	9 (29.0)	22 (71.0)	3.967	1.798	8.752	<0.001				
No	172 (9.3)	1668 (90.7)								
Lenght of hospital stay (day)	6 (1-52)	3 (1-79)				<0.001				

SSI: Surgical site infection**, OR:** Odds ratio**, C.I.:** Confidence interval**, BMI**: Body mass index, **ASA**: American Society of Anesthesiologist

Emergency surgery increases the risk of all complications, especially SSI, due to dysoxia, perfusion disorder, bleeding, coagulopathy, acidosis, and the accompanying organ failure. These factors inherently put this population at increased risk of all complications particularly those associated with the development of infection (21). Zhang et al. reported that emergency surgery significantly increased the incidence of SSI in patients who performed colorectal surgery (22). Alkaaki et al. reported that emergency surgery was an independent variable for SSI in their patients who performed abdominal surgery (23). Fernandez-Moure et al. found the rate of SSI after emergency surgery to be 15.2%, and Zhang X et al. found it to be 24.3%. In our study, emergency surgery was found to be an independent variable for SSI risk in all patients (p = 0.003). We performed 1143 abdominal surgeries in our study. In patients who had abdominal surgery, SSI incidence of emergency surgery was higher than that of elective surgery (22.6% vs 10.9%, p <0.0001). Fernandez-Moure et al. found emergency surgical conditions (peritoneal contamination, ulcer perforation, mesenteric ischaemia, gastrointestinal bleeding and ectopic pregnancy rupture), weight loss, and radiation history as independent risk factors for SSI. In our study, we did not perform additional analysis for emergency surgery conditions; however, we found weight loss as an independent risk factor for SSI (OR: 1.610, p=0.04). In addition, while superficial and deep SSI were seen more frequently in emergency abdominal surgery (13.1% vs 5.6%, p<0.0001 and 5.8% vs 2.0%, p=0.002; respectively), there was no seen difference between the two groups in terms of organ/space SSI (3.7% vs 3.3%, p=0.72) (Table 5).

Table 5. The effect of emergency and elective surgery on surgical site infection in abdominal surgery

Parameters	Abdominal surgerytiming		p
	Elective (n=815)	Emergency (n=328)	
Surgical site infection			
(n, %)	46 (5.6)	43 (13.1)	<0.0001
Superficial	16 (2.0)	19 (5.8)	0.002
Deep	27 (3.3)	12 (3.7)	0.72
Organ/space	89(10.9)	74 (22.6)	<0.0001
Total			

SSI incidence of laparoscopic surgery is lower than that of open surgery due to smaller surgical incision, less surgical trauma and postoperative complications, shorter hospital stay, and faster recovery (24,25). It has been reported that laparoscopic surgery reduces the SSI incidence in appendectomy (26), in gastrectomy (27), in cholecystectomy (24), in colectomy (28), and in gastric bypass surgery (29). We performed 1275 abdominal surgeries in our study. In our study, we found that the incidence of SSI was lower in laparoscopic surgery compared to open surgery (2.2% vs 24.0%, p < 0.001). However, while this decrease in SSI rates was significant in appendectomy, cholecystectomy, and morbid obesity surgeries, it was not significant in gastrectomy and colectomy surgeries (Table 6).

Table 6. The effect of surgical technique type on surgical site infection in abdominal surgery

Parameters	Abdominal surgery type		p
	Open (n=678)	Laparoscopy (n=597)	
Surgical site infection (n,			
%)	94 (13.9)	3 (0.5)	<0.001
Superficial	37 (5.5)	3 (0.5)	<0.001
Deep	32 (4.7)	7 (1.2)	0.0002
Organ/space	163 (24.0)	13 (2.2)	<0.001
Total			
Surgical site infection (n,			
%)	19 (19.8)	1 (2.6)	0.01
Appendectomy	13 (17.1)	3 (11.5)	0.76
Gastrectomy	14 (25.5)	3 (0.9)	<0.001
Cholecystectomy	41 (30.8)	5 15.6)	0.12
Colectomy	3 (100.0)	1 (0.8)	<0.001
Morbis obesity surgery			

In general, the operative time depends on the surgeon's experience and intraoperative problems such as iatrogenic organ injury, bleeding or conversion to open surgery (30). As the operation time increases, the surgical team's adherence to the rules of asepsis and antisepsis decreases, thereby increasing the risk of surgical contamination. This causes SSI rates to increase (30, 31). In our study, we found long operation duration (≥240 minutes) to be an independent variable for SSI risk, similar to the findings of Kurmann et al. (30).

The main goal of using drains in the clinic is to detect complications such as bleeding or anastomotic leakage early (32). However, it has been shown that drains increase SSI by increasing inflammation at the surgical site and causing bacterial contamination along the drain surface (33). In a systematic meta-review by Wu et al., drains were not found to be useful for the prevention of SSI following abdominal surgeries (gastrectomy, colorectal, liver, and pancreas) (32). Two systematic reviews showed that drain placement in elective cholecystectomy increases the incidence of SSI (34, 35). A Cochrane review and meta-analysis reported different results regarding the effect of drain placement on SSI incidence in complicated appendicitis (p = 0.21, p < 0.0001; respectively) (36, 37). In our study, we found the use of drains to be an independent variable increasing SSI. We found that using a drain increases both superficial, deep and organ/space SSI. We found that using drains increased the rate of SSI only in clean-contaminated wounds (16.2% vs. 5.4%, p <0.001). We established that for clean-contaminated wound, the use of drains reduced SSI only in appendectomy and cholecystectomy (%23.2 vs %8.2, p=0.03 and, %6.3 vs%0.7, p=0.009; respectively) but did not reduce SSI in gastrectomy, colectomy and morbid bariatric surgery (p=0.35, p=0.20, p=0.57; respectively) (Table 7).

This study has several limitations. In this study, we did not evaluate patient-related and surgery-related factors that may have affected the incidence of SSI, such as operating room conditions, sterilization of surgical materials, personal surgical hygiene, and glucose control. The choice of antibioprophylaxis, resistant pathogenic microorganism type, antibiotic susceptibility tests, surgical technique and experience, and complication management may differ between centers. In addition, pilonidal sinus surgery with a high risk of CAI was not included in the study. All these factors may have affected the outcome of our study.

Table 7. The effect of drain placement on surgical site infection in wound classification, abdominal with non-abdominal surgery and clean-contaminated surgery types

Parameters	Drain (+) n=1270	Drain (-) n=601	p
Surgical site infection (n, %)			
Superficial	89 (7.0)	12 (2.0)	<0.001
Deep	35 (2.8)	6 (1.0)	0.02
Organ/space	37 (2.9)	2 (0.3)	<0.001
Total	161 (12.7)	20 (3.3)	<0.001
Surgical site infection (n, %)			
Clean wound	12 (2.7)	6 (2.0)	0.63
Clean-contamined	122 (16.2)	16 (5.4)	<0.001
Contamined	12 (37.5)	0 (0)	0.54
Clean-contamined wound (n, %)			
Appendectomy	14(23.0)	6 (8.2)	0.03
Cholecystectomy	17 (6.3)	1 (0.7)	0.009
Bariatric surgery	4 (4.5)	0 (0)	0.57
Gastrectomy	16 (17.2)	0 (0)	0.35
Colectomy	43)29.7)	3 (15.0)	0.20

In conclusion, in our study, we found that preoperative weight loss, clean-contaminated wounds, general anesthesia, emergency surgery, open surgical technique, prolonged operation duration (≥4 hours), drain placement, and distant infection were risk factors for SSI. In order to reduce SSI incidence in general surgical procedures, identification of patients with preoperative >10% weight loss should be done, laparoscopic technique should be preferred in abdominal surgeries, the surgical technique should be improved to shorten the operation duration and reduce blood transfusion, and drain placement should be avoided, especially in clean-contaminated wounds.

Conflict of interest
The authors declares that they have no conflict of interest.

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Authors' contributions
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Ethical Statement
This prospective cohort study was approved by the Malatya Clinical Research Ethics Committee (decision number: 2017/118). All procedures performed were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

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