ORIGINAL ARTICLE

Risk of surgical site infections after colorectal surgery and the most frequent pathogens isolated: a prospective single-centre observational study

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ABSTRACT

Aim To identify risk factors for developing surgical site infections (SSIs) based on a prospective study of patients undergoing colorectal surgery.

Methods Between November 2019 and January 2021, 133 patients underwent elective operation for colorectal cancer in our institution. The following variables were recorded for each patient: age, gender, body mass index (BMI), American Society of Anesthesiologists Classification (ASA class), duration of surgery, wound classification, skin preparation regimens, surgical approach, comorbidities (hypertension, diabetes, cardiovascular disease, respiratory disease, chronic steroid use), and pathogens responsible for surgical site infection. Univariate analysis was performed using χ^2 tests for categorical variables.

Results A total of 65 males and 68 females were enrolled. Postoperative SSI was diagnosed in 29 (21.8%) cases. Fifty five patients were >70 years old, and SSIs were significantly more frequent in this group (p=0.033). There were 92 patients with BMI <30kg/m^2 and 87 with ASA class ≤2; SSIs occurred significantly less frequently in these patients (p=0.021 and p=0.028, respectively). Open surgery was performed in 113 patients; 35 (out of 113; 31%) wound infections were classified as contaminated or dirty, and SSI occurred more often in these two groups (p=0.048 and p=0.037, respectively). Nineteen patients had diabetes and 36 used steroids continuously; SSI was significantly more frequent in these patients (p=0.021 and p=0.049, respectively).

Conclusion Following colorectal cancer procedures SSIs were significantly more common among patients over 70 years old, BMI≥30kg/m^2, ASA score>2, with diabetes and chronic steroid use, undergoing open, dirty or contaminated surgery. *Escherichia coli* and *Enterococcus* spp. were the two most common pathogens isolated.

Key words: colorectal cancer, microorganism, risk factor, wound infection

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INTRODUCTION

Surgical site infection (SSI) is one of the most frequent healthcare-associated infections (HAI) among surgical patients (1). According to recent data from the National Nosocomial Infection System (NNIS) of the US Centres for Disease Control and Prevention (CDC), the prevalence of SSI ranges from 2.4% to 21.6% in patients undergoing colorectal surgery (2). The SSI is the most common postoperative complication after colorectal surgery, causing pain and suffering to patients (3). In addition, this complication has been associated with negative economic impact, increased morbidity, extended postoperative hospital stay, readmission, and death (4,5). The process of SSI after colorectal surgery is very complex and involves many factors, such as patient-related factors (age, comorbidities, nutritional status), intra-operative factors (urgent vs elective surgery, open vs laparoscopic method, type of operating field, duration of surgery), and postoperative wound management (6).

The Centres for Diseases Control and Prevention (CDC) defined infection of a surgical site as: superficial incisional surgical site infection (SSI-S), deep incisional surgical site infection (SSI-D), and organ/space surgical site infection (SSI-O). In SSI-S only the skin and subcutaneous tissues are involved. They develop within 30 days from surgery and the diagnostic criteria include the presence of at least one symptom of infection (reddening, swelling, elevated skin temperature, or tenderness), isolated pathogen of material collected after surgical opening of the incision site, purulent drainage from the surgical incision, diagnosis of SSI-S by the attending physician or surgeon. One of these criteria has to be met. In SSI-D deeper tissues are involved, including fascial and muscle layers. Patients with SSI-D have at least one of the following criteria: wound dehiscence, purulent drainage from the deep surgical incision but not from the organ component of the surgical site, evidence of abscess formation, diagnosis of SSI-D by the attending physician or surgeon. SSI-O involves any part of the anatomy in organs and spaces other than the incision, which was opened and manipulated during the surgical procedure. Patients with SSI-O have at least one of following criteria: pathogens isolated from a culture of fluid or tissue in the organ, evidence of abscess formation involving the organ/space, purulent drainage from a drain that is placed into the organ/space, diagnosis of SSI-O by the attending physician or surgeon (7,8).

According to the literature, *Escherichia coli* (*E. coli*), *Pseudomonas aeruginosa* (*P. aeruginosa*), and gram-positive cocci (especially *Enterococcus*) are the most frequent isolated pathogens from patients with SSI after colorectal surgery. However, differences in the pathogens causes may exist depending on the type of the colorectal surgery (left-sided vs right-sided operations) (9,10).

The aim of this study was to identify the risk factors for developing SSI based on a prospective analysis of patients undergoing colorectal surgery in a single centre between November 2019 and January 2021.

PATIENTS AND METHODS

Patients and study design

This prospective trial was conducted at the General University Hospital of Patras in Greece, an 800-bed tertiary Hospital in South-Western Greece that covers the population of approximately 1.5 million people, between November 2019 and January 2021, and included 133 patients undergoing elective operation for colorectal cancer.

Inclusion criteria were patients older than 18 years, preoperative hospital stay less than 48 hours, elective surgery, and diagnosis of colorectal cancer that was scheduled to be treated by elective colorectal surgery. Exclusion criteria were patients younger than 18 years old, preoperative hospital stay more than 48 hours, emergency surgery, placement of ileostomies or colostomies, and other non-malignant colorectal diseases (infectious bowel disease or diverticulitis). The patients gave their informed written consent for the study. The day prior to surgery patients underwent preparation of large bowel as well as antibiotic prophylaxis based on standards established at our Institution: 2nd generation cephalosporin and metronidazole administered 30 minutes before the first skin incision, and two doses of each antibiotic administered again after four hours of operation.

All operations were conducted by the same group of surgeons and anaesthesiologists. Patients received either a poviodone-iodine antisepsis regimen, or chlorhexidine-alcohol skin preparation regimen.

The day before the surgery, all patients provided their written informed consent.

An ethical approval was obtained from the Ethics Committee of the General University Hospital of Patras (No 5461/40626-11/11/2019).

Methods

After patient's extubating in the operating room, surgical information was recorded (surgery time, intra-operative complications). Following surgery, patients were transferred to the surgical ward. The patient follow-up and the surveillance of the surgical wound, as well as data collection and analysis were carried out by our team of surgeons from the day of the surgery until hospital discharge.

The following variables were recorded for each patient: age (≤70 or >70 years), gender (male/female), body mass index (BMI <30 or ≥30), American Society of Anesthesiologists Classification (ASA; ≤2 - healthy patients or with a mild systemic disease, or >2 - patients with at least one severe systemic disease) (11), duration of surgery (≤240 minutes or >240 minutes), wound classification (clean/clean contaminated, or contaminated/dirty), skin preparation regimens (poviodone-iodine antisepsis or chlorhexidine-alcohol), surgical approach (open or laparoscopic), comorbidities (hypertension, diabetes, cardiovascular disease, respiratory disease, and continued steroid use), and pathogens responsible for SSI. The criteria used to define SSI were those established by the Centers for Diseases Control and Prevention (CDC) (7).

Statistical analysis

A univariate analysis was performed using χ^2 test for categorical variables to compare results between the groups (SSI group vs non-SSI group). A p< 0.05 was considered statistically significant.

RESULTS

From November 2019 to January 2021 a total of 133 patients with colorectal cancer, including 65 males and 68 females, met the inclusion criteria for this prospective study. Postoperative SSI was diagnosed in 29 (21.8%) patients. In 20 (15%) patients diagnosed with SSI the infection was superficial, in eight (6%) deep, and in one patient (0.8%) infection involving an organ space was found (Table1).

Table 1. Postoperative surgical site infections (SSI) in 133 patients undergoing colorectal surgery

Patient groups	No (%) of patients
Non-SSI	104
SSI (according to classification)	29 (21.8)
Superficial (SSI-S)	20 (15.0)
Deep incisional (SSI-D)	8 (6.0)
Organ/space (SSI-O)	1 (0.8)

The univariate analysis showed no difference with regard to SSI prevalence depending on patient gender, skin preparation, duration of the procedure, and comorbidities (hypertension, cardiovascular and respiratory disease). The SSIs were significantly more frequent in the group of patients >70 years old (55; 41.35%) comparing to that one of <70 (30.91% vs 15.38%; p=0.033). There were 92 (69.17%) patients with BMI <30kg/m^2 and 87 (65.41%) with ASA class ≤2 in which SSI occurred significantly less frequently: 16.3% vs 34.15% (p=0.021) and 16.09% vs 32.61% (p=0.028), respectively.

An open approach was used in 113 (84.96%) procedures, of which 35 (26.32%) wounds were classified as contaminated or dirty. SSI occurred more often in these patients comparing to the patients with laparoscopic approach and the patients with clean wounds (24.78% vs 5%; p=0.048 and 34.29 vs 17.35; p=0.037, respectively).

Nineteen (out of 133; 14.29%) patients were found to have had diabetes and 36 (27.07%) used steroids; SSI was significantly more frequent in these two groups of patients comparing to the patients who had not had diabetes or used steroids (42.11% vs 18.42%; p=0.021 and 33.33 vs 17.35; p=0.049, respectively) (Table 2).

Six different microbial pathogens were detected from 25 SSIs of patients who underwent surgery for colorectal cancer: *Escherichia coli* in 11 (44%) and *Enterococcus* spp. in six (24%) cases were the two most common pathogens (Table 3).

Table 3. Prevalence of microbial pathogens detected after colorectal surgery

Pathogen	No (%) of patients
Escherichia coli	11 (44.00)
Enterococcus spp.	6 (24.00)
Klebsiella pneumonia	3 (12.00)
Pseudomonas aeruginosa	3 (12.00)
Staphylococcus aureus	1 (4.00)
Candida albicans	1 (4.00)

Table 2. Univariate analysis of demographic and clinical characteristics of the patients with and without surgical site infection (SSI)

Variable	No (%) of patients in the group				
	Total (n=133)	**SSI** (n=29)	**non-SSI** (n=104)	**SSI %**	**p**
Age					
≤ 70	78 (58.65)	12 (41.38)	66 (63.46)	15.38	0.033
>70	55 (41.35)	17 (58.62)	38 (36.54)	30.91	
Gender					
Male	65 (48.87)	15 (51.72)	50 (48.08)	23.08	0.448
Female	68 (51.13)	14 (48.28)	54 (51.92)	20.59	
BMI (kg/m2)					
< 30	92 (69.17)	15 (51.72)	77 (74.04)	16.30	0.021
≥ 30	41 (30.83)	14 (48.28)	27 (25.96)	34.15	
ASA class					
≤ 2	87 (65.41)	14 (48.28)	73 (70.19)	16.09	0.028
> 2	46 (34.59)	15 (51.72)	31 (29.81)	32.61	
Duration of surgery					
> 240 minutes	25 (18.80)	7 (24.14)	18 (17.31)	28.00	0.405
≤ 240 minutes	108 (81.20)	22 (75.86)	86 (82.69)	20.37	
Wound classification					
Clean or clean contaminated	98 (73.68)	17 (58.62)	81 (77.88)	17.35	0.037
Contaminated or dirty	35 (26.32)	12 (41.38)	23 (22.12)	34.29	
Skin preparation					
Poviodone-iodine	74 (55.64)	16 (55.17)	58 (55.77)	21.62	0.954
Chlorhexidine-alcohol	59 (44.36)	13 (44.83)	46 (44.23)	22.03	
Surgical approach					
Open	113 (84.96)	28 (96.55)	85 (81.73)	24.78	0.048
Laparoscopic	20 (15.04)	1 (3.45)	19 (18.27)	5	
Comorbidities					
Hypertension					
Yes	71 (53.38)	19 (65.52)	52 (50.00)	26.39	0.139
No	62 (46.62)	10 (34.48)	52 (50.00)	16.13	
Diabetes					
Yes	19 (14.29)	8 (27.59)	11 (10.58)	42.11	0.021
No	114 (85.71)	21 (72.41)	93 (89.42)	18.42	
Cardiovascular disease					
Yes	17 (12.78)	6 (20.69)	11 (10.58)	35.29	0.149
No	116 (87.22)	23 (79.31)	93 (89.42)	19.83	
Respiratory disease					
Yes	28 (21.05)	8 (27.59)	20 (19.23)	28.57	0.329
No	105 (78.95)	21 (72.41)	84 (80.77)	20.00	
Chronic steroid use					
Yes	36 (27.07)	12 (41.38)	24 (23.08)	33.33	0.049
No	97 (72.93)	17 (58.62)	80 (76.92)	17.53	

DISCUSSION

Surgery of colorectal cancer has been associated with high risk of postoperative complications. The SSIs are one of the most common postoperative complication following colorectal procedures with many negative consequences for patients, such as extended hospital stay, morbidity, readmission, and death (12,6). Because of the increase in the SSIs incidence after elective and urgent admissions, there is an increase in the cost of care at discharge from hospital per patient (13). The additional average cost is estimated to be 20.000 dollars per infection (14). According to recent data from CDC (14), SSIs represent 22% of all healthcare–associated infections (HAIs), and approximately 15% are associated with colorectal operations. For these reasons, reduction of SSI rates in patients undergoing colorectal surgeries remains an observable priority for surgical quality improvement. In addition, the incidence of SSI after colorectal operations ranges from 3% to 30 % (4,15). However, there are not many trials studying the risk of SSIs especially for oncologic operations. There is a study in the literature finding SSI rate of 25% in which more than 600 patients underwent elective surgery for colorectal cancer (16). In our study, the prevalence of SSIs was 21.8% and the majority of them were superficial (15%).

The outcomes of this prospective study suggest that there was no statistically significant difference in the presence of SSI among patients who received a proviodone-iodine antisepsis regimen versus a chlorhexidine-alcohol skin preparation regimen. According to the literature, more than 70% of all SSIs arise from the micobieme of the patients, and the perioperative failure to control their microbieme has as a result the occurrence of infections (17). In a study by Darouiche et al. 849 patients undergoing clean-contaminated surgery were randomized to receive either proviodone-iodine scrub, or chlorhexidine-alcohol. The chlorhexidine-alcohol skin preparation regimen was superior for preventing SSI (18).

It is worth mentioning that the major findings of this prospective study were that age >70 years, BMI ≥30kg/m^2, ASA score >2, dirty/contaminated surgery, open surgery, as well as comorbidities (diabetes and chronic steroid use) were associated with significantly higher incidence of SSIs.

Like the study of Kamboj et al., our study demonstrated that the prevalence of SSIs significantly differed according to the patients' BMI, ASA score, wound classification, surgical approach, and comorbidities (diabetes and chronic steroid use) (4). However, in our study SSIs prevalence was affected by patient's age, like the study of Banaszkiewicz et al., whereas Kamboj et al. did not find significant difference (4,6). This can be explained by the difference in age-groups that each study used. Specifically, we compared patients below or over 70 years old, whereas Kamboj et al. and Banaszkiewicz et al. made comparison between patients below or over 65 and 75 years of age, respectively.

We found that the open procedure was a risk factor for the appearance of SSIs, as it is demonstrated in many studies (1,19). Laparoscopic approach is an independent protective factor after colorectal surgery and is associated with a reduced risk of SSIs (10).

Six different microbial pathogens were detected from 25 SSIs after surgery for colorectal cancer in the present study, mostly *Escherichia coli* and *Enterococcus* spp. This result is consistent with the Chinese SSI surveillance study reported by Du et al., in which *Escherichia coli* and *Enterococcus* spp. were the two most common pathogens in patients undergoing colorectal surgery (10).

One limitation of this study that should be considered is that we did not record data of patients undergoing urgent surgeries as well as cases with an intestinal stoma (ileostomy or colostomy). According to the literature, the placement of an intestinal stoma is considered to be a significant risk factor for SSI (12,20). Furthermore, the development of SSI is much more frequent among patients undergoing urgent surgeries (6,12). A retrospective analysis of 310 patients with colorectal cancer conducted by Bayar et al. showed that SSI was significantly more frequent among patients undergoing urgent colorectal procedure (26.7% vs 10.9%) (21). Another limitation of our study is the small number of participants from a single centre.

In conclusion, our study indicates the need for a prospective randomized controlled trial having a larger number of participants.

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TRANSPARENCY DECLARATION

Conflict of interests: None to declare.

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