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The influence of laparoscopic and conventional surgical approaches on the development of surgical site infections in colon cancer

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ABSTRACT

Introduction: Minimal invasive surgery techniques are getting more popular by surgeons relying their advantages such as pain control, feasibility and increased affinity. Both techniques have similar prognostic influence regarding survival in colon cancer but increased versatility of laparoscopy in years shows more tendency of laparoscopy among surgeons. This study aims to evaluate of surgical site infection (SSI) rates between conventional and laparoscopic colon cancer procedures.

Materials and Methods: Patients operated due to colon adenocarcinoma between 2018 and 2023 evaluated. Emergency, palliative or incomplete resections excluded. Demographic, pathologic, peroperative and postoperative records of patients evaluated. Patients seperated into groups by SSI occurance and surgical method choice.

Results: SSI development was found higher in conventional surgery group (30.0% vs 11.6%; p=0.013). In comparison of patients by SSI development; only intraoperative Red Blood Concentrate (RBC) replacement founded to be higher in SSI (+) group (0±1 vs 0±1; p=0.002). All variables associated with SSI development were subjected to univariate regression analysis. It's shown that only conventional surgery choice was a indipendant risk factor for SSI development (OR: 3.489 (1.289 – 9.415); p=0.017).

Conclusion: Laparoscopic colon surgery has better SSI rates than conventional colon surgery procedures. Our findings are similar with the general view on SSI ratio's between two surgical practices.

Keywords: Colon Cancer, Laparoscopy, Surgical site infection

Introduction

The selection of minimally invasive techniques is becoming increasingly popular among surgeons today. The growing preference for these procedures is driven by the cumulative experience gained over time and the early exposure of new surgeons to these techniques at the start of their practice. As a result, minimally invasive surgical procedures are being chosen more frequently for a vari-

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ety of cases.[1] In general surgical practice, laparoscopy is gaining ground and popularity daily, extending its use from benign conditions, such as cholecystectomy, to oncological procedures for gastric, colon, and pancreatic cancers, and even to more confined areas.[1-4]

There are several reasons that explain the increased adoption of these procedures, despite their higher cost compared to conventional surgical methods. Firstly, minimal incision techniques result in smaller wounds, leading to less postoperative pain and enabling patients to return to their daily activities more quickly. These fundamental advantages make laparoscopy a more favorable option and warrant its consideration over open surgical methods.[5]

In addition to these advantages, although it has been noted that there is an initial learning curve and longer operative times associated with the first use of these techniques, recent studies have shown that these concerns have been mitigated. Furthermore, it has been demonstrated that minimally invasive techniques offer additional benefits, such as reduced complication rates and improved resection quality.[5,6]

Surgical site infections (SSIs) are one of the most frequently attributed advantages of laparoscopy in recent literature reviews. Numerous studies have indicated that the use of laparoscopy significantly reduces the incidence of SSIs.[7,8] This study aims to evaluate the impact of the chosen surgical method on the development of SSIs in patients who underwent surgery for colon adenocarcinoma at our center.

Materials and Methods

Approval was obtained from the Ethics Committee of Koşuyolu Yüksek İhtisas Training and Research Hospital on 03/09/2024, with reference number 2024/15/900. The records of patients who underwent laparoscopic or conventional colon cancer procedures in the Department of Gastrointestinal Surgery at the same center between 01/01/2018 and 12/31/2023 were reviewed.

Patients who underwent palliative, emergency, or inadequate oncological surgery were excluded. Additionally, any patient lacking complete data on laboratory, pathology, or demographic information, or with follow-up shorter than 30 days, was excluded. The patients' demographic data, comorbidities, pathology results, intraoperative fluid measurements and types (if recorded), intraoperative records, and postoperative ward round records for SSI definitions were evaluated.

Intravenous cefazolin prophylaxis at a dose of 2 or 3 grams, depending on the patient's weight, was administered 60 minutes before surgery, along with 500 mg of metronidazole prophylaxis at 7-hour intervals for all patients.[9] A single anesthesia team was responsible for the preoperative and intraoperative management of the patients. No mechanical bowel preparation was administered since rectal cancer patients were excluded. At least one drain was placed at the operation site in all procedures. Skin sterilization was performed using chlorhexidine. SSIs were defined according to the Centers for Disease Control and Prevention (CDC) 1988 classifications, with 2017 modifications. SSIs were classified as Superficial Surgical Site Infection (SSSI), Deep Surgical Site Infection (DSSI), and Organ/Space Infection (OSI).[10,11] Patients who developed at least one of these subtypes were confirmed as having developed an SSI.

Two analyses were performed on groups formed based on the choice of operation method and the development of SSI. The first analysis compared patients who underwent conventional surgery with those who had laparoscopic surgery. In the second analysis, patients who developed SSI were compared with those without infection. Demographic and clinical data, diagnoses, intraoperative measurements, perioperative and postoperative lactate measurements, and postoperative length of stay (LOS) were compared between these groups.

Statistical analyses were conducted using the SPSS 27.0 (SPSS Inc., Chicago, IL) software package. The normality of quantitative variables was assessed using the Kolmogorov-Smirnov test. Independent samples t-tests were used for comparison of normally distributed variables between independent groups, while the Mann-Whitney U test was used for non-normally distributed variables. The relationship between qualitative variables was explored using chi-square analysis. Descriptive statistics for normally distributed quantitative variables were presented as mean±standard deviation, while non-normally distributed quantitative variables were presented as median (25^{th}-75^{th} percentile). Descriptive statistics for qualitative variables were expressed as frequencies (%). p-values less than 0.05 were considered statistically significant.

Results

A total of 162 patients were included in the study. Regarding the origin of the lesions, 30 were in the cecum, 44 in the ascending colon, 8 in the transverse colon, 22 in the descending colon, and 58 in the sigmoid colon. A total of 42 patients developed an SSI. Among these 42 patients, 39 had a Superficial Surgical Site Infection (SSSI), 14 had a Deep Surgical Site Infection (DSSI), and 10 had an Organ/Space Infection (OSI). When comparing patients based on the surgical method, the proportion of diabetic patients was higher in the laparoscopic group (68.9% vs. 86%; p=0.029). Additionally, the prevalence of coronary artery disease (CAD) was higher in the laparoscopic group (64.7% vs. 83.7%; p=0.020). Age was higher in the conventional surgery group (65±12 vs. 58±14 years; p=0.002), as was Body Mass Index (BMI) (27.99±4.97 vs. 26.49±3.72; p=0.003). Other demographic and pathological variables were similar between the groups.

In the comparison of intraoperative findings, operation time was significantly longer in the laparoscopy group (188±58 vs. 244±50 minutes; p<0.001). Intraoperative fluid replacement was also more restricted in the laparoscopy group (2300±1900 vs. 2380±840 mL; p=0.008). Finally, SSI development was higher in the conventional surgery group (30.0% vs. 11.6%; p=0.013). Other demographic, pathological, and intraoperative variables are presented in Table 1.

In the comparison of patients based on SSI development, only intraoperative red blood cell (RBC) transfusion was higher in the SSI (+) group (0±1 vs. 0±1; p=0.002). All other demographic, pathological, and intraoperative variables were similarly distributed between the groups (Table 2).

All variables associated with SSI development in Tables 1 and 2 were subjected to univariate regression analysis. It was shown that only the choice of conventional surgery was an independent risk factor for SSI development (OR: 3.489 [1.289–9.415]; p=0.017). None of the other variables were found to be independent risk factors for SSI development (p>0.05). Since all parameters, except the choice of conventional surgery, were found to be insignificant, these variables were not included in a further multivariate Cox regression analysis to evaluate their prognostic relationship with SSI development (Table 3).

Discussion

In our study, it was demonstrated that patients undergoing conventional surgery are at a higher risk of developing SSI compared to those undergoing laparoscopic surgery. The incidence of SSI in patients who underwent laparotomy was approximately 3.5 times higher than in those who underwent laparoscopy. Today, one of the most significant factors in the preference for minimally invasive surgical procedures is the improvement in patients' postoperative quality of life. Hospital stay duration, which is closely related to SSIs, is one of the many factors affecting the early return to daily life. A lower rate of SSI development is one of the most crucial factors that enable patients to resume their daily activities as soon as possible.[12] Although there are publications showing that SSI development can even affect prognosis determination, there is no clear consensus on this matter.[13-15]

The incidence of SSIs following colorectal cancer surgery can reach up to 20%, according to the literature. The development of SSIs also prolongs hospital stays and increases cost estimates, maintaining its relevance among surgical specialties.[12] Studies conducted under the US surgical education improvement program have shown that not only colorectal procedures but also surgical procedures related to other organs are associated with a decreased incidence of SSIs in minimally invasive procedures.[16] The reasons cited for this include better surgical visualization, smaller incisions, and a reduced systemic inflammatory response associated with minimally invasive procedures.[17]

There are numerous recent studies on this topic, which is central to surgical practice. In a study comparing minimally invasive techniques, cases of laparoscopy and robotic surgery were evaluated, and it was found that neither method had an advantage over the other in terms of SSI development. However, the study showed that bleeding exceeding 100 ml, a history of diabetes, and incision size were independent risk factors for SSI development.[12] Although our study also demonstrated that a history of diabetes and intraoperative bleeding were significant for SSI development, they were not found to be independent risk factors in multivariate analyses. Since our study compared open surgery with laparoscopy cases, incision sizes were not evaluated. We only included colon cancer patients. Our study demonstrated that the incidence of SSI was lower with the choice of minimally invasive surgery.

Table 1. Demographic and pathologic variable analysis depending on laparoscopy choice

Variables	Conventional n=119 (73.5%)	Laparoscopy n=43 (26.5%)	p, †
Gender			
Male	63 (61.3%)	25 (58.1%)	0.713
Female	46 (38.7%)	18 (41.9%)	
Hypertension			
No	50 (42%)	24 (55.8%)	0.120
Yes	69 (58%)	19 (44.2%)	
Diabetes			
No	82 (68.9%)	37 (86%)	0.029*
Yes	37 (31.1%)	6 (14%)	
CAD			
No	77 (64.7%)	36 (83.7%)	0.020*
Yes	42 (35.3%)	7 (16.3%)	
COPD			
No	107 (89.9%)	38 (88.4%)	0.777
Yes	12 (10.1%)	5 (11.6%)	
Anemia			
No	103 (86.6%)	38 (88.4%)	0.761
Yes	16 (13.4%)	5 (11.6%)	
Tumor Site			
Caecum	23 (19.3%)	7 (16.3%)	0.221
Right Colon	32 (26.9%)	12 (27.9%)	
Transverse Colon	8 (6.7%)	0 (0.0%)	
Left Colon	18 (15.1%)	4 (9.3%)	
Sigmoid Colon	38 (31.9%)	20 (46.5%)	
T Stage			
T1	6 (5%)	3 (7%)	0.360
T2	7 (5.9%)	6 (14%)	
T3	85 (71.4%)	28 (65%)	
T4	21 (17.6%)	6 (14%)	
N Stage			
N0	74 (62.2%)	24 (55.8%)	0.763
N1	28 (23.5%)	12 (27.9%)	
N2	17 (14.3%)	7 (16.3%)	
M Stage			
M0	109 (91.6%)	43 (100%)	0.062
M1	9 (7.6%)	0 (0%)	
Neoadjuvant Chemotheraphy			
No	118 (99.2%)	1 (100%)	0.547
Yes	43 (0.8%)	0 (0%)	
LVI			
Negative	79 (66.4%)	24 (55.8%)	0.193
Positive	39 (32.8%)	19 (44.2%)	
PNI			
Negative	89 (74.8%)	31 (72.1%)	0.688
Positive	29 (25.2%)	12 (27.9%)	

Table 1. Demographic and pathologic variable analysis depending on laparoscopy choice (CONT.)

Variables	Conventional n=119 (73.5%)	Laparoscopy n=43 (26.5%)	p, †
Grade			
Good	17 (14.3%)	9 (20.9%)	0.483
Moderate	83 (71.4%)	30 (69.8%)	
Poor	17 (14.3%)	4 (9.3%)	
Stage			
I	10 (0.1%)	6 (14%)	0.199
II	60 (50%)	20 (46.5%)	
III	40 (33.6%)	17 (39.5%)	
IV	9 (16.3%)	0 (0%)	
SSI			
No	82 (70%)	38 (88.4%)	0.013*
Yes	37 (30%)	5 (11.6%)	
ASA Score			
1	5 (4.2%)	3 (7%)	0.329
2	40 (33.6%)	15 (34.9%)	
3	66 (55.5%)	25 (58.1%)	
4	8 (6.7%)	0 (0%)	
Anastomosis Leakage			
No	115 (96.6%)	42 (97.7%)	0.736
Yes	4 (3.4%)	1 (2.3%)	
	Mean±SD	**p‡**	
Age	65±12	58±14	0.002**
BMI	27.99±4.97	26.49±3.72	0.003**
Operation Time / minutes	188±58	244±50	<0.001***
Intraoperative RBC Replacement / per unite	0±1	0±1	0.055
Postoperative RBC Replacement / per unite	1±2	1±1	0.128
Peroperative Fluid Replacement / mL	2300±1900	2380±840	0.008**
Peroperative Bleeding /mL	137±114	92±112	0.357

CAD: Coronary Artery Disease; COPD: Chronic Obstructive Pulmonary Disease; LVI: Lymphıvascular Invasion; PNI: Perineural Invasion; SSI: Surgical Site Infection; BMI: Body Mass Index; ASA: American Society of Anesthesiology; RBC: Red Blood Cell Concentrate; mL: milliliter; LOS: Length of Hospital Stay; SD: Standard Deviation; * p<0,05, **p<0,01, ***p<0.001, † Chi-Square, ‡ Indipendent t Test.

In a separate study involving 670 patients who underwent laparoscopic colorectal surgery, factors affecting the development of SSI were evaluated. It was shown that the use of polydioxanone suture (PDS) for abdominal closure and a history of diabetes could influence SSI development, with multivariate analysis indicating that only the use of PDS reduced the risk of SSI.[18] The study mentioned that only intracorporeal stapled anastomosis was performed and described the areas and incisions used for specimen extraction. However, the rates of conversion to open surgery were not reported. In parallel with our study, demographic factors such as bleeding, operative time, anemia, and BMI were not found to be associated with SSI development.

In another large-scale prospective study involving over 3,000 laparoscopic cases, factors affecting SSI development were evaluated. Cases were compared based on colon and rectal surgeries. It was shown that rectal

Table 2. Demographic and pathologic variable analysis depending on SSI

Variables	SSI (-) n=120 (74.1%)	SSI (+) n=42 (25.9%)	p, †
Gender			
Male	71	27	0.559
Female	49	15	
Hypertension			
No	55	19	0.947
Yes	65	23	
Diabetes			
No	88	31	0.952
Yes	32	11	
CAD			
No	86	27	0.370
Yes	34	15	
COPD			
No	109	36	0.352
Yes	11	6	
Anemia			
No	105	36	0.767
Yes	15	6	
Tumor Site			
Caecum	22	8	0.910
Right Colon	32	12	
Transverse Colon	5	3	
Left Colon	16	6	
Sigmoid Colon	45	13	
T Stage			
T1	8	1	0.242
T2	12	1	
T3	82	31	
T4	18	9	
N Stage			
N0	73	25	0.924
N1	30	10	
N2	17	7	
M Stage			
M0	114	38	0.197
M1	5	4	
Neoadjuvant Chemotheraphy			
No	119	42	
Yes	1	0	
LVI			
Negative	71	32	0.055
Positive	48	10	
PNI			
Negative	86	34	0.267
Positive	33	8	

Table 2. Demographic and pathologic variable analysis depending on SSI (CONT.)

Variables	SSI (-) n=120 (74.1%)	SSI (+) n=42 (25.9%)	p, †
Grade			
Good	21	5	0.703
Moderate	83	30	
Poor	15	6	
Stage			
I	14	2	0.374
II	59	21	
III	42	15	
IV	5	4	
ASA Score			
1	6	2	0.859
2	40	15	
3	69	22	
4	5	3	
Anastomosis Leakage			
No	115	42	0.179
Yes	5	0	
	Mean±SD	**p‡**	
Age	63±13	63±2	0.542
BMI	27.35±4.43	28.29±5.42	0.268
Operation Time / minutes	205±61	194±60	0.585
Intraoperative RBC Replacement / per unite	0±1	0±1	0.002**
Postoperative RBC Replacement / per unite	1±2	1±1	0.587
Peroperative Fluid Replacement / mL	2328±1028	2300±1040	0.732
Peroperative Bleeding / mL	117±118	148±104	0.322

CAD: Coronary Artery Disease, COPD: Chronic Obstructive Pulmonary Disease, LVI: Lymphıvascular Invasion, PNI: Perineural Invasion, SSI: Surgical Site Infection, BMI: Body Mass Index, ASA: American Society of Anesthesiology, RBC: Red Blood Cell Concentrate, LOS: Length of Hospital Stay, mL: milliliter, sd: Standard Deviation, * p<0,05, **p<0,01, † Chi-Square, ‡ Indipendent t Test.

Table 3. Cox Regression Analysis for Dependants Effecting Surgical Site Infection

	Univariant		
Prognostic Factors	**OR**	**95% CI**	**p**
Conventional Surgery	3.489	1.249 – 9.415	0.017*
Diabetes	0.976	0.439 – 2.167	0.952
CAD	1.405	0.667 – 2.962	0.371
Age	1.000	0.972 – 1.029	0.994
Operation Time / minutes	0.997	0.991 – 1.003	0.316
Intraoperative RBC Replacement / per unite	0.634	0.347 – 1.161	0.140
Peroperative Fluid Replacement / mL	0.877	1.000 – 1.000	1.000

CAD: Coronary Artery Disease, RBC: Red Blood Cell Concentrate OR: Odds Ratio, CI: Confidence Interval, * p<0,05.

surgery led to a higher incidence of SSI compared to colon surgery.[19] In our study, however, rectal cancer patients were not included due to differences in oncological principles and the influence of neoadjuvant therapy as a significant factor. Finally, in a study evaluating readmissions, it was shown that patients who underwent laparoscopic colon surgery had lower rates of SSI development, shorter hospital stays, and reduced rates of re-laparotomy, bleeding, and 30-day mortality.[20] Similarly, in our study, the rates of SSI development and bleeding were lower in patients who underwent laparoscopic surgery.

The main limiting factor of our study is its retrospective design. Although the culture growth results of most patients were accessible in the hospital records, in some cases, the outcomes had to be determined by evaluating infection records, which means that while the presence of growth was documented, the specific pathogen could not be identified. Additionally, including all colon segments may lead to heterogeneity due to potential differences in incision types and anastomosis techniques. The strengths of our study include complete patient follow-up records and the exclusion of rectal cancer patients and those who received neoadjuvant therapy to prevent bias.

The incidence of SSI is lower in patients undergoing laparoscopic colon resection compared to those who undergo open surgery. When evaluating other factors influencing SSI development, we believe it would be appropriate to consider the choice of minimally invasive surgery in conjunction with these other factors.

Conclusion

The preference for laparoscopy in colon cancer significantly reduces the incidence of SSI. Although our study showed that factors such as diabetes and bleeding also influenced SSI development, only the choice of laparoscopy was found to be an independent risk factor. It is suggested that more specific studies could be conducted by comparing standard surgical preferences and anastomosis techniques in open and laparoscopic cases, focusing on isolated surgical procedures targeting specific anatomical regions of the colon.

Disclosures

Ethics Committee Approval: Approval was obtained from the Ethics Committee of Koşuyolu Yüksek İhtisas Training and Research Hospital on 03/09/2024, with reference number 2024/15/900. The records of patients who underwent laparoscopic or conventional colon cancer procedures in the Department of Gastrointestinal Surgery at the same center between 01/01/2018 and 12/31/2023 were reviewed.

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