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Retrospective Study

# Incidence of surgical site infection in minimally invasive colorectal surgery

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## Abstract

### BACKGROUND

Surgical site infection (SSI) is a common complication of colorectal surgery. Minimally invasive surgery notably reduces the incidence of SSI. This study aimed to compare the incidences of SSI after robot-assisted colorectal surgery (RACS) *vs* that after laparoscopic assisted colorectal surgery (LACS) and to analyze associated risk factors for SSI in minimally invasive colorectal surgery.

### AIM

To compare the incidences of SSI after RACS and LACS, and to analyze the risk factors associated with SSI after minimally invasive colorectal surgery.

### METHODS

Clinical data derived from patients who underwent minimally invasive colorectal surgery between October 2020 and October 2022 at the First Affiliated Hospital of Soochow University were collated. Differences in clinical characteristics and surgery-related information associated with RACS and LACS were compared, and possible risk factors for SSI were identified.

### RESULTS

A total of 246 patients (112 LACS and 134 RACS) were included in the study. Fortythree (17.5%) developed SSI. The proportions of patients who developed SSI were similar in the two groups (17.9% *vs* 17.2%,  $P = 0.887$ ). Diabetes mellitus, intraoperative blood loss  $\geq 100$  mL, and incision length were independent risk factors for SSI. Possible additional risk factors included neoadjuvant therapy, lesion site, and operation time.

### CONCLUSION

There was no difference in SSI incidence in the RACS and LACS groups. Diabetes mellitus, intraoperative blood loss  $\geq 100$  mL, and incision length were independent risk factors for postoperative SSI.

**Key Words:** Colorectal surgery; Minimally invasive surgery; Surgical site infection

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**Core Tip:** The application of robotic surgery in colorectal surgery is becoming increasingly widespread. While it brings convenience of operation, it is still unclear whether it increases the risk of surgical site infection (SSI). The current study compared the incidences of SSI in robot-assisted colorectal surgery and laparoscopic-assisted colorectal surgery, and analyzed potential risk factors associated with SSI after minimally invasive colorectal surgery, to provide guidance for clinical practice.

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## INTRODUCTION

According to World Health Organization (WHO) guidelines, surgical site infection (SSI) is defined as an infection that occurs within 30 d after an operation and involves the skin and subcutaneous tissue of the incision (superficial incisional) and/or the deep soft tissue (for example fascia and muscle) of the incision (deep incisional) and/or any part of the anatomy (for example organs and spaces) other than the incision that was opened or manipulated during an operation [1]. Common risk factors for SSI include preoperative diabetes mellitus, contaminative incision, excess subcutaneous fat, advanced age, obesity, and emergency surgery [2,3].

Colorectal surgical incision is a type II incision. Pathogens that often colonize the digestive tract may cause SSI. According to relevant studies, patients undergoing colorectal surgery are particularly at risk of SSI, with the infection rate as high as 26% [4,5]. Therefore, SSI is one of the most common early complications after colorectal surgery, which often leads to an increase in costs and hospitalization and even affects oncologic outcomes [6-8].

The application of robotic surgery is currently increasing, but it is expensive and involves issues such as installing and removing machines, resulting in longer surgery times. Robotic surgery brings convenience, but it is not clear whether it increases the risk of incision infections. The current study compared the incidences of SSI after robot-assisted colorectal surgery (RACS) and laparoscopic assisted colorectal surgery (LACS), and analyzed potential risk factors associated with SSI after minimally invasive colorectal surgery.

## MATERIALS AND METHODS

### Patient characteristics

This retrospective study included 246 patients who underwent minimally invasive colorectal surgery (LACS or RACS) at the General Surgery Department of the First Affiliated Hospital of Suzhou University from October 2020 to October 2022. The inclusion criteria were: (1) Patients scheduled to undergo elective radical surgery, and preoperative preparation was complete; (2) the minimally invasive surgery undergone was the first operation since admission; (3) age range 18-90 years; and (4) the operation was performed by the same general surgeon with experience in robotic surgery and laparoscopic surgery. The exclusion criteria were: (1) Patients who underwent open surgery or emergency surgery; (2) patients with active infection or a purulent cavity in the operation area before surgery; and (3) patients who were lost to follow-up.

According to existing guidelines, the patients all met the scope of minimally invasive colorectal surgery. The choice of surgical method was based on the patients' wishes. The study was approved by the Ethics Committee of the First Affiliated Hospital of Soochow University. Written informed consent was obtained from all patients.

Age, gender, body mass index (BMI), American Society of Anesthesiologist (ASA) grade, history of past illness, pathology, and relevant laboratory examinations were reviewed *via* the electronic medical record information system. The operation data collected included operation time, operation site, anastomosis method, intraoperative blood loss, time of postoperative intake, and incision length.

All patients were administered cefazolin (1 g) or cefthiamidine (1 g) *via* intravenous drip 0.5-1.0 h before the operation. If the surgery time was > 3 h, additional cefazolin (1 g) or cefthiamidine (1 g) was administered during the operation. In patients with cephalosporin allergy, an intravenous drip of etimicin 0.1 g was used instead. Antibiotics were administered 12 h and 48 h after the operation.

The main outcome measure was the incidence of SSI within 30 d after surgery. SSI was diagnosed based on WHO guidelines. Observation index information was mainly obtained *via* telephone calls and outpatient follow-up.

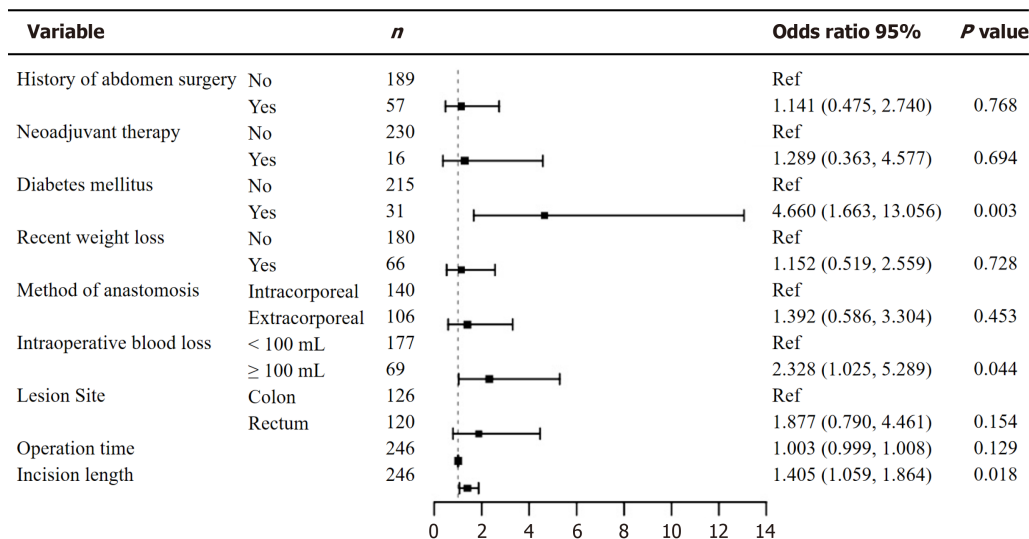


Figure 1 Forest plot illustrating the results of multivariate analysis for risk factors of surgical site infection.

### Statistical analysis

All statistical analyses were performed using SPSS software (version 26.0). The two-tailed *t*-test was used for continuous variables, unless the data were non-normally distributed. In such cases the Mann-Whitney U test was used to assess comparisons. The  $\chi^2$  test or Fisher's exact test were used for categorical variables, which were summarized as frequencies and percentages. All collected variables were analyzed using univariate logistic analysis, and those with  $P < 0.15$  were selected for inclusion in multivariable logistic analysis. All statistical analyses were two-sided, and  $P < 0.05$  was considered statistically significant.

## RESULTS

### Clinical characteristics and surgical results

A total of 246 patients were included in the study, 112 who underwent LACS and 134 who underwent RACS. The clinical characteristics of the patients are shown in Table 1. The age of the patients in the LACS and RACS groups was similar (64 years *vs* 66 years,  $P = 0.105$ ), and most were male. Twenty-eight (11.4%) had a history of smoking, 97 (39.4%) had a history of hypertension, and 31 (12.6%) had diabetes mellitus. More patients in the LACS group received neoadjuvant therapy before surgery (9.8% *vs* 3.7%,  $P = 0.054$ ) and there was more intraoperative blood loss in the LACS group (44.6% *vs* 14.2%,  $P < 0.001$ ). The mean operation time was longer in the RACS group (281 min *vs* 243 min,  $P = 0.004$ ). The anastomosis method was similar in the two groups. The incidences of SSI were similar in the two groups (17.9% *vs* 17.2%,  $P = 0.887$ ), and the overall incidence of SSI was 17.5% (Table 2).

### SSI Risk factors

Demographic and operative information of the cohort by the occurrence or otherwise of SSI is shown in Table 3. In logistic analysis lesion site [odds ratio (OR) 1.996, 95% confidence interval (CI) 1.014-3.929,  $P = 0.045$ ], diabetes mellitus (OR 3.749, 95%CI 1.656-8.484,  $P = 0.002$ ), neoadjuvant therapy (OR 3.130, 95%CI 1.072-9.138,  $P = 0.037$ ), incision length (OR 1.429, 95%CI 1.126-1.815,  $P = 0.003$ ), intraoperative blood loss  $\geq 100$  mL (OR 3.082, 95%CI 1.562-6.084,  $P = 0.001$ ), and long operation time (OR 1.005, 95%CI 1.001-1.009,  $P = 0.006$ ) were predictors of SSI. There was no significant difference in the incidences of SSI in the LACS and RACS groups (OR 0.953, 95%CI 0.493-1.844,  $P = 0.887$ ). Variables with  $P < 0.15$  in the univariate analysis were then included in a multivariate analysis (Figure 1). Independent risk factors for SSI after minimally invasive colorectal surgery indicated in that analysis were diabetes mellitus (OR 4.660, 95%CI 1.663-13.056,  $P = 0.003$ ), intraoperative blood loss  $\geq 100$  mL (OR 2.328, 95%CI 1.025-5.289,  $P = 0.044$ ), and incision length (OR 1.405, 95%CI 1.059-1.864,  $P = 0.018$ ).

## DISCUSSION

SSIs are a common complication of colorectal surgery. In previous studies the overall incidence of SSI after colorectal surgery has ranged from approximately 7% to 26% [4,5,9,10]. The high incidence and various adverse effects of SSI have attracted the attention of surgeons. With advances in minimally invasive surgery the incidence of SSI has decreased significantly. In an analysis of a large database in the United States, minimally invasive surgery was associated with a lower incidence of SSI after surgery than open surgery. This was verified at different surgical sites in another study based



**Table 1 Clinical characteristics, *n* (%)**

	LACS ( <i>n</i> = 112)	RACS ( <i>n</i> = 134)	<i>P</i> value
Age (yr)	64 (56, 70)	66 (58, 72)	0.105
Sex			0.590
Male	78 (69.6)	89 (66.4)	
Female	34 (30.4)	45 (33.6)	
BMI			0.334
< 24	76 (67.9)	83 (61.9)	
≥ 24	36 (32.1)	51 (38.1)	
Lesion site			0.925
Colon	57 (50.9)	69 (51.5)	
Rectum	55 (49.1)	65 (48.5)	
ASA			0.188
I-II	98 (87.5)	109 (81.3)	
III-IV	14 (12.5)	25 (18.7)	
Hypertension			0.407
No	71 (63.4)	78 (58.2)	
Yes	41 (36.6)	56 (41.8)	
Diabetes mellitus			0.415
No	100 (89.3)	115 (85.8)	
Yes	12 (10.7)	19 (14.2)	
Hyperlipidemia			0.291
No	79 (70.5)	86 (64.2)	
Yes	33 (29.5)	48 (35.8)	
Smoking history			0.919
No	99 (88.4)	119 (88.8)	
Yes	13 (11.6)	15 (11.2)	
History of abdomen surgery			0.534
No	84 (75.0)	105 (78.4)	
Yes	28 (25.0)	29 (21.6)	
Previous operation except abdomen surgery			0.801
No	82 (73.2)	100 (74.6)	
Yes	30 (26.8)	34 (25.4)	
Tumor marker			0.730
Normal	93 (83.0)	109 (81.3)	
Abnormal	19 (17.0)	25 (18.7)	
Liver function			0.599
Normal	107 (95.5)	126 (94.0)	
Abnormal	5 (4.5)	8 (6.0)	
Albumin			0.366
≥ 40	63 (56.3)	83 (61.9)	
< 40	49 (43.8)	51 (38.1)	
Preoperative CRP			0.687

Normal	82 (73.2)	95 (70.9)	0.109
Abnormal	30 (26.8)	39 (29.1)	
Uric acid			0.109
Normal	98 (87.5)	107 (79.9)	
Abnormal	14 (12.5)	27 (20.1)	0.378
Recent weight loss			
No	85 (75.9)	95 (70.9)	0.054
Yes	27 (24.1)	39 (29.1)	
Neoadjuvant therapy			0.054
No	101 (90.2)	129 (96.3)	
Yes	11 (9.8)	5 (3.7)	

ASA: American Society of Anesthesiologists; BMI: Body mass index; CRP: C-reactive protein; LACS: Laparoscopic-assisted colorectal surgery; RACS: Robot-assisted colorectal surgery.

**Table 2 Surgery results, *n* (%)**

	LACS ( <i>n</i> = 112)	RACS ( <i>n</i> = 134)	<i>P</i> value
Pathology			
Benign	49 (43.8)	47 (35.1)	0.165
Malignant	63 (56.3)	87 (64.9)	
Method of anastomosis			0.848
Intracorporeal	63 (56.2)	77 (57.5)	0.549
Extracorporeal	49 (43.8)	57 (42.5)	
Incision length	(66, 6)	6 (5, 6)	< 0.001
Intraoperative blood loss			
< 100 mL	62 (55.4)	115 (85.8)	0.004
≥ 100 mL	50 (44.6)	19 (14.2)	
Operation time	243 (212, 305)	281 (239, 317)	0.783
Time of postoperative intake (d)	2 (2, 3)	2 (2, 3)	
SSI			0.887
No	92 (82.1)	111 (82.8)	
Yes	20 (17.9)	23 (17.2)	

LACS: Laparoscopic-assisted colorectal surgery; RACS: Robot-assisted colorectal surgery; SSI: Surgical site infection.

on the prospective database of the National Surgical Quality Improvement Program for major surgical procedures[11]. Compared with open surgery, laparoscopic surgery can result in a smaller incision length, clearer surgical vision, and a milder systemic inflammatory reaction, which helps to reduce the occurrence of SSI[12].

Since the launch of the da Vinci surgical robot in 2000, minimally invasive surgery has undergone significant changes. It was initially approved for use in general surgeries. Over the past 20 years robotic surgery has undergone further development, and its indications are expanding, covering all fields of abdominal gastrointestinal surgery. Robotic surgery systems can enable operators to obtain three-dimensional and more precise vision, and they can compensate for surgeons' hand tremors, so that they can perform more complex surgical operations[13]. Many retrospective studies and metaanalyses have demonstrated the advantages of robotic surgery in the application of abdominal digestive surgery, such as reducing hospitalization times and intraoperative bleeding. However, few studies have compared the incidences of SSI after robotic and laparoscopic surgery[14-17].

The total incidence of SSI in the current study was 17.5%, which is within the range of previously reported incidences of SSI mentioned above. There was also no significant difference in the incidences of postoperative SSI in the LACS and RACS groups ( $P = 0.887$ ). Robotic surgery does not seem to reduce the incidence of postoperative SSI. This may be due to

**Table 3 Risk factors for the development of surgical site infection, *n* (%)**

	Non-SSI ( <i>n</i> = 203)	SSI ( <i>n</i> = 43)	OR	95%CI	<i>P</i> value
Sex					
Male	136 (76.0)	31 (72.1)	Ref		
Female	6 (33.0)	12 (27.9)	0.786	0.380-1.627	0.516
Age	65 (57, 71)	64 (57, 72)	1.006	0.976-1.037	0.697
BMI					
< 24	134 (66.0)	25 (58.1)	Ref		
≥ 24	69 (34.0)	18 (41.9)	1.398	0.714-2.738	0.328
Pathology					
Benign	80 (39.4)	16 (37.2)	Ref		
Malignant	123 (60.6)	27 (62.8)	1.098	0.556-2.165	0.788
Lesion site					
Colon	110 (54.2)	16 (37.2)	Ref		
Rectum	93 (45.8)	27 (62.8)	1.996	1.014-3.929	0.045
ASA					
I-II	172 (84.7)	35 (81.4)	Ref		
III-IV	31 (15.3)	8 (18.6)	1.268	0.538-2.991	0.587
Hypertension					
No	125 (61.6)	24 (55.8)	Ref		
Yes	78 (38.4)	19 (44.2)	1.269	0.652-2.467	0.483
Diabetes mellitus					
No	184 (90.6)	31 (72.1)	Ref		
Yes	19 (9.4)	12 (27.9)	3.749	1.656-8.484	0.002
Hyperlipidemia					
No	140 (69.0)	25 (58.1)	Ref		
Yes	63 (31.0)	18 (41.9)	1.600	0.815-3.142	0.172
Smoking history					
No	178 (87.7)	40 (93.0)	Ref		
Yes	25 (12.3)	3 (7.0)	0.534	0.154-1.856	0.324
History of abdomen surgery					
No	160 (78.8)	29 (67.4)	Ref		
Yes	43 (21.2)	14 (32.6)	1.796	0.873-3.695	0.111
Previous operation except abdomen surgery					
No	151 (74.4)	31 (72.1)	Ref		
Yes	52 (25.6)	12 (27.9)	1.124	0.538-2.349	0.756
Tumor marker					
Normal	167 (82.3)	35 (81.4)	Ref		
Abnormal	36 (17.7)	8 (18.6)	1.060	0.454-2.477	0.892
Liver function					
Normal	194 (95.6)	39 (90.7)	Ref		
Abnormal	9 (4.4)	4 (9.3)	2.211	0.648-7.541	0.205
Preoperative albumin					

≥ 40	124 (61.1)	22 (51.2)	Ref		
< 40	79 (38.9)	21 (48.8)	1.498	0.773-2.902	0.231
Uric acid					
Normal	166 (81.8)	39 (90.7)	Ref		
Abnormal	37 (18.2)	4 (9.3)	0.460	0.155-1.367	0.162
Recent weight loss					
No	153 (75.4)	27 (62.8)	Ref		
Yes	50 (24.6)	16 (37.2)	1.813	0.904-3.637	0.094
Neoadjuvant therapy					
No	193 (95.1)	37 (86.0)	Ref		
Yes	10 (4.9)	6 (14.0)	3.130	1.072-9.138	0.037
Method of anastomosis					
Intracorporeal	120 (59.1)	20 (46.5)	Ref		
Extracorporeal	83 (40.9)	23 (53.5)	1.663	0.858-3.221	0.132
Incision length	6 (5, 7)	6 (6, 6)	1.429	1.126-1.815	0.003
Intraoperative blood loss					
< 100 mL	155 (76.4)	22 (51.2)	Ref		
≥ 100 mL	48 (23.6)	21 (48.8)	3.082	1.562-6.084	0.001
Operation time	260 (215, 312)	301 (243, 334)	1.005	1.001-1.009	0.006
Time of postoperative intake (d)	2 (2, 3)	2 (2, 3)	1.241	0.737-2.091	0.416
Preoperative CRP					
Normal	147 (72.4)	30 (69.8)	Ref		
Abnormal	56 (27.6)	13 (30.2)	1.137	0.554-2.337	0.726
Surgery approach					
LACS	92 (45.3)	20 (46.5)	Ref		
RACS	111 (54.7)	23 (53.5)	0.953	0.493-1.844	0.887

ASA: American Society of Anesthesiologists; BMI: Body mass index; CRP: C-reactive protein; LACS: Laparoscopic-assisted colorectal surgery; RACS: Robot-assisted colorectal surgery; SSI: Surgical site infection.

the methods of anastomosis and specimen extraction in robotic surgery being similar to those used in laparoscopic-assisted surgery at present. In a sense, the advantage of robotic surgery lies in optimizing the surgeon's senses and operability, and there is no significant advantage in terms of SSI.

The independent risk factors for SSI identified in the current study were diabetes mellitus (OR 4.660, 95%CI 1.663-13.056,  $P = 0.003$ ), intraoperative blood loss  $\geq 100$  mL (OR 2.328, 95%CI 1.025-5.289,  $P = 0.044$ ) and incision length (OR 1.405, 95%CI 1.059-1.864,  $P = 0.018$ ), which was similar to the results of previous studies[18]. The occurrence of SSI in patients with diabetes mellitus may be due to the fact that hyperglycemia interferes with the normal metabolism of cells and produces excessive reactive oxygen species, leading to blocked blood circulation and reduced tissue perfusion. In addition, hyperglycemia can activate the inflammatory pathway, reduce immune function, facilitate the growth of bacteria, and prolong the healing time of the anastomosis. Increased intraoperative blood loss may lead to tissue hypoxia, and a longer incision may increase the risk of pathogen contamination. In the current study RACS had a longer mean operation time than LACS, but this did not lead to a significant difference in the incidence of SSI. There were no significant associations between SSI and BMI, smoking history, high ASA grade, or low albumin level in the present study.

The study had some limitations. It was retrospective, the sample size was relatively small, and there was some bias. There are also differences between colonic surgery and rectal surgery. Considering the fact that both the colon and the rectum belong to the digestive tract, they were included in the analysis and discussion; but this is another limitation of the study. Moreover, due to insufficient medical records there were few clinical indicators. A prospective study incorporating large samples, multiple centers, and multiple indicators could be conducted to verify the results of the current study.

## CONCLUSION

In the present study there was no difference in SSI incidences after RACS and LACS. RACS involved less bleeding, but required longer operation times. In logistic regression analysis diabetes mellitus, intraoperative blood loss, and incision length were independent risk factors for SSI.

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## FOOTNOTES

**Co-first authors:** Lu-Ting Ni and Ru Zhao.

**Author contributions:** Ni LT, Zhao R, Ye YR performed the data extraction; Ni LT, Zhao R performed the primary literature; Ouyang YM analyzed the data; Chen X designed the research study and revised the manuscript for important intellectual content; and all authors read and approved the final version. Ni LT and Zhao R contributed equally to this work. The reasons for designating Ni LT and Zhao R as co-first authors are threefold. Firstly, the research is a team collaboration, and the designation of co-first authors accurately reflects the equal contributions of the two individuals, especially in terms of primary literature writing and data collection. Secondly, the completion of the study requires different people to provide different assistance, and designating co-first authors can bring different perspectives to the study and enrich the content of the research. Thirdly, co-first authors can reflect their respective efforts and contributions, and better reflect the spirit of teamwork. In summary, we believe that designating Ni LT and Zhao R as co-first authors is suitable for our manuscript as it accurately reflects team spirit and equal contribution.

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