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ORIGINAL RESEARCH

Analysis of short-term outcome indicators and risk factors for postoperative complications in patients with sigmoid colon cancer by transumbilical single-port plus one port laparoscopy

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Abstract

This study aimed to compare the efficacy of Single-Port plus One Port Laparoscopy (SILS + 1) with Conventional Multi-Port Laparoscopic Surgery (CLS) and investigate risk factors associated with postoperative complications in patients with sigmoid colon cancer undergoing laparoscopy. Male patients with sigmoid colon cancer treated at our hospital were selected and evenly distributed into the CLS and SILS + 1 groups and further categorized into complication and non-complication groups based on their complications status within 30 days post-surgery. Compared to the CLS group, the SILS + 1 group had significantly shorter incision length, greater distance to the lower edge of the tumor and shorter time to first postoperative ambulation ($p < 0.05$). A total of 20 cases (16.67%) developed complications within 30 days post-surgery, and among them, 8 (13.33%) were in the SILS + 1 group and 12 (20.00%) in the CLS group ($p = 0.327$). Logistic multivariable regression analysis showed that age ($p = 0.028$; Odds Ratio (OR) = 1.028; 95% confidence interval (CI): 1.003–1.054), body mass index (BMI) ($p = 0.002$; OR = 1.950; 95% CI: 1.248–2.961) and operation time ($p < 0.001$; OR = 1.067; 95% CI: 1.030–1.106) were independent risk factors for complication occurrence within 30 days post-surgery, and at 2-year follow-up, there was no significant difference in overall survival between both groups ($p > 0.05$). In conclusion, age, BMI and duration of surgery were identified as independent risk factors for postoperative complications in male sigmoid colon cancer patients, among whom SILS + 1 was found to reduce postoperative discomfort and accelerate recovery compared to CLS while maintaining surgical efficacy.

Keywords

Sigmoid colon cancer; Laparoscopic surgery; Single-incision plus one port laparoscopic surgery; Postoperative complications; Risk factors

1. Introduction

Colorectal cancer is a common malignancy affecting the digestive tract, with the rectum and the rectosigmoid junction being the primary sites and sigmoid colon cancer being the most prevalent subtype. In addition, colorectal cancer is influenced by factors such as geographic location and dietary habits and is typically diagnosed in middle-aged and elderly individuals. Surgical intervention is the primary curative approach for colorectal cancer [1, 2]. However, due to the significant harm in terms of invasiveness and related postoperative complications associated with open surgery, laparoscopic surgery, known for its easier maneuverability and lower postoperative complication rates, is the preferred surgical mode in clinical practice.

In colorectal cancer surgery, the conventional 5-port method laparoscopic technique (CLS) has been widely adopted [3]. However, it still has certain limitations, such as the requirement for highly cooperative assistants and the potential for inexperienced assistants to inadvertently cause mesentery tearing and bleeding during the exposure process, which, in turn, limits the degree of minimally invasive procedures [4]. In addition, CLS surgery involves the need for a large incision and numerous Trocar holes, often resulting in painful incisions and suboptimal aesthetic outcomes. In response to these challenges, the single incision laparoscopic surgery (SILS) technique emerged as an alternative approach, and although the safety and feasibility of SILS for colorectal cancer have been established, issues such as coaxial alignment, exposure difficulties and the need for specialized instruments have hindered its wider adoption. In recent years, single-incision plus one port laparoscopic surgery (SILS + 1) has been increasingly proposed as a means to mitigate these technical challenges [5].

Generally, it is believed that SILS + 1 is less likely to cause infections and trauma to the patient's internal environment compared to CLS, which may lead to improved and faster recovery. However, relevant reports regarding the application of SILS + 1, specifically in cases of sigmoid colon cancer, are limited.

An important concern for patients following surgery is the occurrence of surgical complications, and studies have indicated that the incidence of postoperative complications after laparoscopic radical surgery for colorectal cancer varies from 5% to 31% [6], which primarily encompass issues such as stomal leaks, anastomotic bleeding, postoperative intestinal obstructions, and genitourinary system injuries. The presence of these postoperative complications not only leads to increased patient expenses and prolonged hospital stays but also delays the initiation of adjuvant therapy. Notably, several studies have demonstrated a strong correlation between postoperative complications in colorectal cancer patients and their long-term survival rates [7, 8]. However, considering that numerous factors, including patients' clinical characteristics, surgical technique used, perioperative care and underlying disease complex pathogenetic pathways, may influence the likelihood of experiencing postoperative issues, predicting postoperative complications remains challenging for gastrointestinal surgeons.

The main objectives of this study, involving 120 male patients undergoing radical sigmoidectomy, were to evaluate the effects of SILS + 1 on clinical outcomes and identify risk factors for postoperative complications to inform the selection of surgical approaches and postoperative care for male patients with sigmoid colon cancer.

2. Materials and methods

2.1 Patients

The data of male patients diagnosed with sigmoid colon cancer and treated at our hospital were retrieved for this study. They were then evenly divided into two groups: the CLS group and the SILS + 1 group in a 1:1 ratio. The CLS group underwent conventional laparoscopic radical sigmoidectomy surgery, as per the guidelines outlined in the Guidelines for the Diagnosis and Treatment of Colorectal Cancer, while the SILS + 1 group underwent single-incision plus one-hole laparoscopic radical sigmoidectomy surgery.

The study inclusion criteria were: (1) age between 18 and 80 years old; (2) tumor located in the sigmoid colon; (3) histopathology biopsy confirming colon adenocarcinoma; (4) preoperative clinical staging of $T_{1-4a}N_{0-3}M_0$ according to the 7th edition of the AJCC Cancer Staging Manual; (5) tumor diameter of 5 cm or smaller; (6) compliance with laparoscopic surgery indications without absolute contraindications; (7) a simplified activity status score of 0–2 according to the Eastern United States Oncology Collaborative Group; (8) American Society of Anesthesiologists classification I–III; (9) no prior radiotherapy, drug therapy, or targeted therapy.

Patients with the following criteria were excluded: (1) preoperative examinations suggesting presence of distant metastasis or significant local extravasation; (2) conditions such as bleeding, perforation, or obstruction necessitating emergency surgery; (3) concurrent surgery required for other conditions; (4) presence of severe heart, brain, lung, or other vital organ diseases incompatible with surgery; (5) coagulation disorders and portal hypertension not manageable through bleeding control during or after the operation; (6) prior history of major abdominal surgery with extensive abdominal adhesions; (7) severe mental or neurological disorders; (8) familial polyps or malignant inflammatory bowel disease; (9) body mass index (BMI) exceeding 30 kg/m^2; (10) poor compliance and inability to adhere to regular follow-up.

The study comprised 120 male patients diagnosed with sigmoid colon cancer, among whom 60 were allocated to the CLS group and the remaining 60 to the SILS + 1 group (Table 1).

2.2 Surgical procedures

Upon admission, preoperative preparations were conducted for patients from both groups, and all surgical procedures were conducted by the same surgical team.

In the CLS group, tracheal intubation and inhaled general anesthesia drugs were administered, and the patients were placed in the lithotomy position for the surgical procedures. Pneumoperitoneum was successfully established through umbilical puncture, with the pneumoperitoneum pressure set at 15 mmHg. A transverse incision is made in the lower abdomen. Instruments were introduced into the lower abdomen through trocar incisions. The peritoneum on the right side of the colon was carefully separated along the surface of the abdominal aorta using an ultrasonic knife. Subsequently, the inferior mesenteric artery and inferior mesenteric vein were meticulously severed by clamping and ligating at the origin of the inferior mesenteric artery. Following the clearance of lymphatic adipose tissue from the root of the mesenteric vessels, the right lateral peritoneum of the sigmoid rectum was isolated. After the complete liberation of the sigmoid colon, the pelvic lateral peritoneum was dissected. Sharp separation of the descending-sigmoid lateral peritoneum, at least 12 cm distal to the tumor in the sigmoid colon, was performed after determining the location of the tumor proximal and distal to the bowel's cut end. A segment of the colonic mesentery was excised to ensure that the bowel anastomosis was tension-free. The sigmoid colon was then closed 10 cm from the lower edge of the tumor to ligate the intestinal collaterals, resect the corresponding colonic mesentery, clear lymphatic and fatty tissues, and remove the specimen. The proximal colon was placed in a disposable anastomotic staple base with a purse-string suture. After the abdominal cavity was carefully irrigated with 0.9% sodium chloride solution, pneumoperitoneum was reestablished. The proximal and distal colon and rectum were anastomosed, ensuring a tension-free anastomosis. Finally, a drain was inserted.

For the SILS + 1 group, the anesthesia used and patient positioning were identical to those in the CLS group. However, a distinct approach was employed for the surgical procedure, in which a single incision was made using an independently developed single-port laparoscopic operating platform (SC135-55/SC, Senscure., Ningbo, China) at the umbilicus, which

TABLE 1. Baseline demographic and clinical pathological features.

Variables	CLS group (n = 60)	SILS + 1 group (n = 60)	*p*-value
Age, year	58.55 ± 7.91	61.02 ± 8.26	0.097
BMI, kg/m^2	23.60 ± 2.74	24.26 ± 2.71	0.189
Diabetes	28	36	0.143
Hypertension	31	30	0.855
Smoking history	46	40	0.224
T stage			
T1	9	7	0.931
T2	13	12	
T3	28	31	
T4	10	10	
N stage			
N0	21	23	0.844
N1	22	19	
N2	17	18	
Tumor differentiation			
High	18	13	0.578
Medium	30	34	
Low	12	13	
Tumor distance from the anus, cm			
15–19 cm	33	25	0.144
20–25 cm	27	35	
Tumor size, cm^3	3.82 ± 0.54	3.79 ± 0.65	0.796
Hemoglobin, g/L	113.57 ± 18.75	116.46 ± 18.24	0.394
Albumin, g/L	37.19 ± 5.68	37.38 ± 4.19	0.832
Total bilirubin, μmol/L	10.69 ± 3.44	10.70 ± 3.89	0.982
White blood cell count, ×10^9/L	6.28 ± 2.40	5.91 ± 1.98	0.358
Platelets, ×10^9/L	268.10 ± 86.34	276.03 ± 77.33	0.597

CLS: Conventional Laparoscopic Surgery; SILS: single incision laparoscopic surgery; BMI: body mass index.

measured 5 cm longitudinally. Then, the single-port laparoscopic operating platform was inserted. A 12 mm incision was made in the right lower abdomen, specifically at Mai's point, where a 12 mm laparotomy device was inserted to serve as the primary operating port. The positioning of the main operating port was adjusted vertically as needed, depending on the tumor location. The intraluminal procedure adhered to the scope of conventional laparoscopic free clearance. Following the surgical procedure, the specimen was extracted through the umbilical incision.

2.3 Observation indicators

The factors recorded and assessed for this study were as follows: (1) Perioperative parameters (Table 2) comprised bleeding volume, surgical duration, incision length, tumor size, the distance between the proximal and distal margins from the tumor's lower edge, and the number of dissected lymph nodes. Postoperative variables, such as the recovery of gastrointestinal function and length of hospital stay, were also recorded. Postoperative pain during physical activity was assessed using the visual analog pain score (VAS), which ranges from 0 to 10 based on the varying degrees of pain severity [9]. (2) Postoperative complications (Table 3) occurring within 30 days post-surgery were systematically documented and encompassed stomal leaks, incision infections, intestinal obstructions, thrombosis events, voiding dysfunction and sexual dysfunction. For this assessment, the patients were categorized into complication and non-complication groups based on the presence or absence of these complications. (3) Short-term prognosis: A 2-year postoperative follow-up was conducted through telephone consultations and outpatient clinic visits, which included the documentation of local recurrence rates, distant metastasis rates, 2-year progression-free survival rates, and overall survival rates.

TABLE 2. Perioperative status of patients in both groups.

Variables	CLS group (n = 60)	SILS + 1 group (n = 60)	p-value
Surgical time, min	117.83 ± 22.44	124.61 ± 25.51	0.124
Intraoperative bleeding, mL	53.40 ± 24.50	57.17 ± 22.78	0.385
Tumor size, cm^3	23.53 ± 7.67	22.95 ± 7.97	0.686
Tumor's lower edge distance, cm	8.95 ± 0.45	9.68 ± 0.81	<0.001
Tumor's upper edge distance, cm	8.67 ± 1.60	8.59 ± 1.39	0.787
No. of resected lymph nodes, n	20.00 ± 5.68	19.00 ± 5.16	0.737
Incision length, cm	4.34 ± 1.54	2.83 ± 0.63	<0.001
Postexhaust time, d	2.44 ± 0.45	2.40 ± 0.38	0.547
Postoperative defecation time, d	4.12 ± 1.07	4.08 ± 1.03	0.814
First postoperative ambulation, d	4.23 ± 0.97	3.67 ± 1.13	0.004
Posthospital stay, d	9.11 ± 1.93	8.90 ± 1.77	0.542
Postoperative VAS score			
3 days postoperative	4.03 ± 0.92	3.17 ± 0.96	<0.001
4 days postoperative	3.12 ± 0.94	2.15 ± 0.97	<0.001
5 days postoperative	1.93 ± 0.86	1.03 ± 0.80	<0.001

CLS: Conventional Laparoscopic Surgery; SILS: single incision laparoscopic surgery; VAS: visual analog pain score.

TABLE 3. Incidence of postoperative complications.

Variables	CLS group (n = 60)	SILS + 1 group (n = 60)	p-value
Postcomplications, n	12 (20.00%)	8 (13.33%)	0.327
Anastomotic bleeding	0	0	
Anastomotic Bleeding	2 (3.33%)	2 (5.00%)	
Abdominitis	2 (3.33%)	1 (1.67%)	
Lung infection	2 (3.33%)	1 (1.67%)	
Incision infection	1 (1.67%)	1 (1.67%)	
Intestinal obstruction	2 (3.33%)	1 (1.67%)	
Cardiopulmonary complications	0	0	
Voiding dysfunction	1 (1.67%)	1 (1.67%)	
Sexual dysfunction	2 (3.33%)	1 (1.67%)	

CLS: Conventional Laparoscopic Surgery; SILS: single incision laparoscopic surgery.

2.4 Statistical analysis

The Kolmogorov-Smirnov test was used to estimate the normal distribution of all results. Continuous variables with a normal distribution are presented as mean ± standard deviation and analyzed using Student's t-test. Count data were analyzed using the χ^2 test or Fisher's exact probability method. Survival curves were generated using the Kaplan-Meier method, and comparisons between the overall and progression-free survival rates of the two groups were conducted using the Log-rank method. Univariate analysis was conducted to identify independent risk factors for postoperative complications, and variables demonstrating statistical significance ($p < 0.05$) were considered for multivariate Logistic regression analysis ($p < 0.05$). A significance level of $p < 0.05$ was considered statistically significant. All statistical analyses were performed using the SPSS software version 23.0 (IBM Corp., SPSS Statistics, Armonk, NY, USA).

3. Results

3.1 Baseline demographic and clinical pathological features

All 120 male patients diagnosed with sigmoid colon cancer successfully underwent sigmoid colon cancer resection using either CLS (n = 60) or single-port laparoscopic surgery (n = 60). The average age of the patients was 59.78 years, and the mean BMI was 23.93 kg/cm^2. There were no statistically significant differences in general patient characteristics, including age, BMI, comorbidities, tumor stage, and differentiation, between the CLS and SILS + 1 groups ($p > 0.05$, Table 1).

3.2 Perioperative status

Our analysis indicated no cases of intraoperative conversion to open surgery. For intraoperative parameters (Table 2), no statistically significant differences were observed between the two groups regarding surgical duration, intraoperative bleeding, tumor volume, distance from the tumor's lower edge and the number of dissected lymph nodes ($p > 0.05$). However, in contrast to the CLS group, the SILS + 1 group demonstrated a statistically significant reduction in total incision length and an increase in the distance of the proximal incision margin from the upper edge of the tumor ($p < 0.05$).

No significant differences were observed between the two groups in regard to postoperative exhaust time, postoperative defecation time and duration of hospitalization ($p > 0.05$). Nevertheless, the SILS + 1 group exhibited a shorter time to first postoperative ambulation compared to the CLS group and experienced less pain on the 3rd to 5th postoperative days ($p < 0.05$).

3.3 Incidence of postoperative complications

A total of 20 cases (16.67%) experienced postoperative complications within 30 days (Table 3). Among them, 8 cases (13.33%) were in the SILS + 1 group, and 12 cases (20.00%) were in the CLS group, with no statistically significant difference observed between the two groups ($p > 0.05$, Table 3). There were no instances of readmission or deaths related to the surgical procedures in both groups within the 30-day postoperative period.

3.4 Univariate analysis

Based on the occurrence of complications within 30 days following surgery, the 120 patients were divided into two groups: the complication group (n = 20) and the non-complication group (n = 100). Univariate analysis revealed significant differences between the two groups regarding age, BMI, operative duration, intraoperative bleeding, history of diabetes mellitus, tumor size, and distance of the tumor from the anus ($p < 0.05$, Table 4).

3.5 Multivariate logistic regression analysis

Significant variables in univariate analysis were included in logistic multifactorial regression analysis, and the results indicated that age (p = 0.028; OR = 1.028; 95% CI: 1.003–1.054), BMI (p = 0.002; OR = 1.950; 95% CI: 1.248–2.961) and surgery duration ($p < 0.001$; OR = 1.067; 95% CI: 1.030–1.106) were independent risk factors for the development of complications within 30 days after surgery in patients with sigmoid colon cancer (Table 5).

3.6 Follow-up

The entire study cohort was followed up until October 2023, during which no cases of local recurrence were observed in either group. The rates of distant metastasis in the CLS and SILS + 1 groups were 6.67% (4/60, including 2 cases each of liver metastasis and peritoneal implantation) and 8.33% (5/60, all involving liver metastasis) ($\chi^2 = 0.120$, $p = 0.729$). The 2-year progression-free survival rates in the CLS and SILS + 1 groups were 93.33% and 91.67%, respectively (log-rank $\chi^2 = 0.013$, $p = 0.908$, Fig. 1), and the 2-year overall survival rates in the CLS and SILS + 1 groups were 100% and 98.33%, respectively ($\chi^2 = 1.008$, $p = 0.315$).

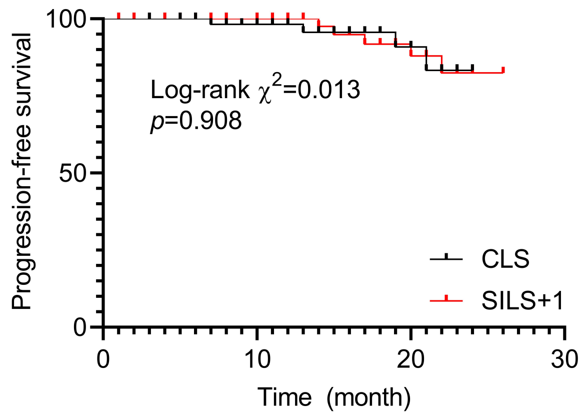

FIGURE 1. Progression-free survival curves for both groups at 2 years of follow-up. CLS: conventional laparoscopic surgery; SILS: single incision laparoscopic surgery.

4. Discussion

In 1992, Pelosi *et al.* [10] pioneered SILS for appendectomy, introducing this technique to gastrointestinal surgery. Then, in 2008, Bucher *et al.* [11] reported the first single-port laparoscopic right hemicolectomy for benign colon tumors. Since then, the use of SILS in colorectal surgery for both benign and malignant conditions has grown. However, SILS demands specialized, expensive instruments and requires surgeons skilled in laparoscopy, and its limited field of view can also make the procedure challenging. As a result, SILS is not widely adopted. SILS + 1 is an improvement on SILS by adding an extra operating port, transitioning from a single-port "small triangle" approach to a "big triangle", which reduces instrument interference and simplifies the procedure.

Zhang *et al.* [12] compared the outcomes of SILS + 1 versus CLS for rectal cancer surgeries and reported no significant differences in terms of operative time, bleeding, surgical margins, lymph node dissection, postoperative hospitalization, and complication rates. However, the SILS + 1 group exhibited a shorter postoperative incision length and lower postoperative pain scores. In contrast, Kawamura *et al.* [13] reported that while SILS + 1 led to quicker recovery, the surgery duration was longer. Yu *et al.* [14] compared SILS, SILS + 1 and CLS colon cancer surgeries and found that SILS + 1 was superior in terms of lymph node clearance and surgery duration compared to the other two groups. In our study, no significant differences were observed between the SILS + 1 and CLS groups in terms of operation time, hospitalization duration and the number of cleared lymph nodes. However, the closer proximal incision margin to the tumor's upper edge in the SILS + 1 group was attributed to the tumor's removal through

TABLE 4. Univariate analysis.

Variables	Non-complication group (n = 100)	Complication group (n = 20)	*p*-value
Age, year	58.21 ± 7.48	67.65 ± 6.78	<0.001
BMI, kg/m^2	23.08 ± 1.34	26.19 ± 1.11	0.001
Diabetes	47	17	0.003
Hypertension	49	12	0.369
Smoking history	72	14	0.856
T stage			
T1	12	4	0.481
T2	22	3	
T3	51	8	
T4	15	5	
N stage			
N0	37	5	0.395
N1	37	7	
N2	26	8	
Tumor differentiation			
High	26	4	0.345
Medium	56	9	
Low	18	7	
Tumor distance from the anus, cm			
15–19 cm	56	2	<0.001
20–25 cm	44	18	
Tumor size, cm^3	3.83 ± 0.60	3.72 ± 0.61	0.475
Hemoglobin, g/L	116.21 ± 18.24	109.04 ± 18.96	0.113
Albumin, g/L	37.18 ± 4.89	37.83 ± 5.47	0.598
Total bilirubin, μmol/L	10.61 ± 3.56	11.14 ± 4.17	0.558
White blood cell count, $\times 10^9$/L	6.20 ± 2.24	5.61 ± 1.92	0.276
Platelets, $\times 10^9$/L	271.75 ± 84.67	273.62 ± 66.76	0.926
Surgical time, min	116.43 ± 21.72	145.15 ± 21.78	<0.001
Intraoperative bleeding, mL	52.73 ± 20.27	68.06 ± 33.91	0.008
Tumor size, cm^3	23.54 ± 7.80	21.71 ± 7.77	0.338
Tumor’s lower edge distance, cm	9.32 ± 0.75	9.29 ± 0.77	0.852
Tumor’s upper edge distance, cm	8.59 ± 1.47	8.82 ± 1.65	0.543
No. of resected lymph nodes, n	20.94 ± 5.45	20.30 ± 5.30	0.631
Incision length, cm	3.62 ± 1.44	3.41 ± 1.12	0.539
Postexhaust time, d	2.40 ± 0.41	2.53 ± 0.41	0.197
Postoperative defecation time, d	4.04 ± 1.02	4.42 ± 1.12	0.135
First postoperative ambulation, d	4.02 ± 1.13	3.63 ± 0.75	0.139
Posthospital stay, d	8.87 ± 1.78	9.68 ± 2.07	0.073
Postoperative VAS score			
3 days postoperative	3.65 ± 1.05	3.35 ± 0.93	0.237
4 days postoperative	2.67 ± 1.10	2.45 ± 0.89	0.403
5 days postoperative	1.49 ± 0.98	1.45 ± 0.76	0.863

BMI: body mass index; VAS: visual analog pain score.

TABLE 5. Multivariate logistic regression analysis.

Variables	β	SE	Wald χ^2	p-value	OR	95% CI
Age	0.028	0.013	4.810	0.028	1.028	1.003–1.054
BMI	0.668	0.213	9.810	0.002	1.950	1.284–2.961
Surgical time	0.065	0.018	12.777	<0.001	1.067	1.030–1.106

SE: standard error; OR: Odds Ratio; CI: confidence interval; BMI: body mass index.

the umbilical incision, which was further from the suprapubic incision to ensure a tension-free anastomosis, thus reducing the length of the proximal resected intestinal collaterals. Liu *et al*. [15] also noted that SILS or SILS + 1 resulted in shorter surgical incisions, lower postoperative pain scores and quicker recovery. In this present study, patients in the SILS + 1 group had lower postoperative pain scores than those in the CLS group from the 3rd to the 5th postoperative day. SILS + 1 surgery led to a reduced number of auxiliary incisions compared to conventional five-hole laparoscopic surgery, resulting in a significantly shorter total incision length, which may explain the lower VAS scores in the SILS + 1 group. Additionally, SILS + 1 facilitated earlier mobilization, faster recovery of postoperative gastrointestinal function and shorter hospitalization, suggesting that SILS + 1 may better preserve postoperative physiological functions. Therefore, concerning the extent of radicality, SILS + 1 offers the advantage of reduced postoperative pain and faster recovery. However, certain studies have indicated that in procedures such as anterior rectal resection and right hemicolectomy, the prolonged postoperative venting time after SILS + 1 surgery might be associated with increased manipulations, such as intestinal clamping due to poor exposure of the operative field after perforation reduction, which may affect intestinal peristalsis [16].

Adding a second 12 mm diameter hole in the right lower abdomen for patients with high rectal and sigmoid colon conditions can effectively separate the surgeon's right hand, which is particularly important during the surgery as this approach significantly simplifies the procedure by minimizing instrument conflicts and providing an effective distraction strategy [17]. Moreover, the additional operating hole can serve as a means for postoperative abdominal drainage, addressing the drawbacks associated with using a single-hole incision for drainage, including suboptimal drainage, a higher risk of incisional infection and the potential for incisional hernia formation. Laparoscopic surgery offers the advantage of minimizing or even preventing damage to patients' autonomic functions, which can occur with open surgery due to the precise separation and dissection of various tissues and organs. Additionally, laparoscopic surgery provides a clearer surgical field of view, facilitating the surgeon's assessment of the patient's visceral peritoneum, mesentery and other tissues. It also allows for more precise approach selection, reducing unnecessary tissue damage and thus preserving patients' postoperative sexual function while lowering the risk of postoperative complications [18]. In this study, we observed that using SILS + 1 for the treatment of sigmoid colon cancer resulted in postoperative urinary function, sexual function, and complication rates similar to those achieved with CLS, thereby highlighting the safety and feasibility of SILS + 1.

Previous studies have demonstrated that laparoscopy can be superior to traditional open surgery [19, 20] but with similar postoperative complication rates. In prospective multicenter clinical studies comparing SILS and CLS, the reported complication rates ranged from 8.4% to 15.0% for CLS and 9.2% to 12.0% for SILS [21–23]. In our present study, the postoperative complication rate for SILS + 1 was 16.67%, slightly higher than that reported in previous studies. We hypothesized that several factors might have contributed to this difference, including staff shortages, equipment issues, communication challenges, limited intraoperative resources and instruments, as well as the attending surgeon's skills. Additionally, a longer surgery duration may have played a contributory role. Research has shown that in elderly colorectal cancer patients, the incidence of postoperative complications ranges from 20% to 30%, with common complications including incision infections, prolonged bowel obstruction and anastomotic fistulas [24, 25]. Multifactorial regression analysis identified age, BMI and surgery duration as risk factors for postoperative laparoscopic radical sigmoidectomy in male patients. The ability to tolerate surgery tends to decrease with age, and the risk of postoperative complications tends to rise due to the gradual decline in organ function, often accompanied by various medical conditions [26–28]. A national study comprising 36,929 colorectal cancer patients in the Netherlands [29] found that BMI was an independent risk factor for early postoperative anastomotic fistula. Similarly, Frasson *et al*. [30] discovered that obesity was an independent risk factor for anastomotic fistula development after radical surgery for colorectal cancer in a multicenter prospective national study involving 3193 patients. Furthermore, the presence of a significant amount of abdominal adipose tissue limits the surgical view, particularly for laparoscopic surgery [31]. Obese individuals are more prone to cardiovascular, respiratory and metabolic conditions and are less resilient to surgical stress [32]. It has been observed that obese patients have a higher likelihood of intraoperative incidents, a slower postoperative recovery and an increased risk of postoperative complications. Hida *et al*. [33] indicated that the duration of surgery influences postoperative complications in rectal cancer, with longer surgery times associated with a higher risk of postoperative complications. Extended surgery durations result in increased exposure of the abdominal cavity, a greater chance of contamination of surgical instruments, an expanded traumatic surface, bleeding, and local hematoma formation. Additionally, longer procedure times can lead to the accumulation of postoperative anesthesia drugs, affecting the body's respiratory, circulatory and digestive systems. In this regard, clinical preventive measures can be implemented based on these identified risk factors to reduce the risk of postoperative complications in colorectal cancer patients.

Given the limitations of a small sample size in this study, it is essential to emphasize that the data and findings may exhibit some degree of bias. Therefore, prospective and clinical trial settings with a larger sample size, multiple centers and long-term follow-up are required for validation. As technology and surgeons' experience continue to advance, SILS + 1 is expected to gain wider acceptance and more effectively demonstrate its advantages in preserving functionality in the field of colorectal cancer surgery.

5. Conclusions

In conclusion, SILS + 1 offers advantages such as reduced postoperative discomfort and quicker recovery compared to CLS without affecting surgical radicality. Age, BMI and surgery duration were identified as independent risk factors for postoperative complications in male sigmoid colon cancer patients and could be considered to guide the selection of surgical approaches and improve postoperative care.

AVAILABILITY OF DATA AND MATERIALS

The authors declare that all data supporting the findings of this study are available within the paper and any raw data can be obtained from the corresponding author upon request.

AUTHOR CONTRIBUTIONS

WJL—designed the study and performed the research; WJL, SYL and WDZ—supervised the data collection; WJL and MMC—analyzed the data; prepared the manuscript for publication and reviewed the draft of the manuscript; WJL, SYL and MMC—interpreted the data. All authors have read and approved the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approval was obtained from the Ethics Committee of Clinical Oncology School of Fujian Medical University, Fujian Cancer Hospital (Approval no. 2020-018-01). Written informed consent was obtained from a legally authorized representative for anonymized patient information to be published in this article.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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