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The primary aim of *World Journal of Gastrointestinal Surgery* (WJGS, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

WJGS mainly publishes articles reporting research results and findings obtained in the field of gastrointestinal surgery and covering a wide range of topics including biliary tract surgical procedures, biliopancreatic diversion, colectomy, esophagectomy, esophagostomy, pancreas transplantation, and pancreatectomy, etc.

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Retrospective Study

Risk factors for anastomotic fistula development after radical colon cancer surgery and their impact on prognosis

Jun Wang, Min-Hua Li

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Abstract

BACKGROUND

Colon cancer is a common malignant tumor in the gastrointestinal tract that is typically treated surgically. However, postradical surgery is prone to complications such as anastomotic fistulas.

AIM

To investigate the risk factors for postoperative anastomotic fistulas and their impact on the prognosis of patients with colon cancer.

METHODS

We conducted a retrospective analysis of 488 patients with colon cancer who underwent radical surgery. This study was performed between April 2016 and April 2019 at a tertiary hospital in Wuxi, Jiangsu Province, China. A *t*-test was used to compare laboratory indicators between patients with and those without postoperative anastomotic fistulas. Multiple logistic regression analysis was performed to identify independent risk factors for postoperative anastomotic fistulas. The Functional Assessment of Cancer Therapy-Colorectal Cancer was also used to assess postoperative recovery.

RESULTS

Binary logistic regression analysis revealed that age [odds ratio (OR) = 1.043, *P* = 0.015], tumor, node, metastasis stage (OR = 2.337, *P* = 0.041), and surgical procedure were independent risk factors for postoperative anastomotic fistulas. Multiple linear regression analysis showed that the development of postoperative anastomotic fistula (*P* = 0.000), advanced age (*P* = 0.003), and the presence of diabetes mellitus (*P* = 0.015), among other factors, independently affected

prognosis.

CONCLUSION

Postoperative anastomotic fistulas significantly affect prognosis and survival rates. Therefore, focusing on the clinical characteristics and risk factors and immediately implementing individualized preventive measures are important to minimize their occurrence.

Key Words: Radical colon cancer surgery; Anastomotic fistula; Risk factors; Prognosis; Life expectancy; Survival rate

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Core Tip: The incidence of anastomotic fistulas after radical colon cancer surgery is high and significantly affects patient prognosis. Additional targeted interventions should be supplemented to reduce the occurrence of anastomotic fistulas and improve the prognosis.

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INTRODUCTION

Colon cancer is a malignant tumor that originates from the colonic epithelium and often occurs at the sigmoid colorectal junction. While its etiology remains unclear, most colon cancers develop from adenomatous polyps and progress to carcinoma. As one of the most prevalent cancers worldwide, colon cancer is the second and third leading cause of cancer-related deaths globally[1] and in the United States, respectively[2]. In China, it is one of the most frequently diagnosed tumors, with an increasing incidence rate[3]. A recent report from the National Cancer Center in China published in the *Journal of the National Cancer Center* revealed that colon cancer is the third and fourth most commonly occurring cancer in women and men, respectively, in China[4]. An increase in the incidence of colon cancer has been reported among younger individuals, with approximately 11% of the cases occurring in those aged < 50 years. This incidence rate also increases by 1%-2% annually[5,6]. The statistics emphasize the current threat of colon cancer poses to human health. Additionally, a study indicated that the 5-year survival rates for patients with colon cancer aged 18-65 years with stages I, II, III, and IV are 91%, 82%, 66%, and 10%, respectively[7]. Furthermore, Dekker *et al*[8] reported that in 2017, approximately 140000 people were diagnosed with colon cancer, and approximately 50000 died from this disease.

Clinical symptoms of colon cancer primarily include abdominal distension, indigestion, and bloody stools. The initial mild symptoms, such as indigestion, bloody stools, and constipation, can progress to edema, jaundice, and ascites in advanced stages. Surgery remains the primary treatment option for patients with early-stage colon cancer, with approximately 20% of patients diagnosed with distant metastases ineligible for surgical resection[9]. Surgical resection is the mainstay of treatment for colon cancer[10]. In recent years, laparoscopic radical colon cancer surgery has become the preferred approach over open surgery because of its advantages including reduced trauma and postoperative pain[11]. However, regardless of the surgical method used, patients with colon cancer are prone to developing anastomotic fistulas following surgery[12]. Anastomotic fistulas are a common and severe postoperative complication following radical colon cancer surgery. If not promptly treated, they can result in permanent stomas, increase the risk of recurrence, and even lead to death[13]. The development of anastomotic fistulas can be attributed to various factors, including poor blood flow due to tight anastomotic sutures, inadequate preoperative intestinal preparation, poor postoperative nutritional status, and improper patient care during the postoperative period. These factors increase the risk of postoperative abdominal infection, further exacerbating the patient's condition[14,15]. Previous studies examined the risk factors associated with the development of anastomotic fistulas after radical colon cancer surgery, but their findings were inconsistent, and none of them investigated the prognostic implications of anastomotic fistulas on patients with colon cancer[12,16]. Therefore, this study aimed to identify independent risk factors for the development of anastomotic fistulas after radical colon cancer surgery and to investigate the effects of these fistulas on patient prognosis. The findings of this study may contribute to improving the postoperative well-being of patients, prolonging their life expectancy, and improving their prognosis.

MATERIALS AND METHODS

Research participants

A total of 488 patients who underwent radical colon cancer surgery at the Affiliated Hospital of Jiangnan University

between April 2016 and April 2019 were included in the study.

The inclusion criteria were as follows: (1) All patients underwent elective surgery; (2) pathological stage of tumor, node, metastasis (TNM) stages I-III; (3) postoperative pathology confirming colon cancer; (4) radical resection of colon cancer surgery; (5) preoperative imaging ruling out liver, lung, and other distant metastases; (6) availability of detailed medical records and complete postoperative pathological data; and (7) informed consent signed by patients and family members.

The exclusion criteria included: (1) Patients who died during hospitalization or were discharged automatically and terminated treatment; (2) patients with a planned stoma; (3) patients with severe coagulation abnormalities; (4) patients with confirmed unresectable tumor invasion of surrounding organs or advanced tumors with distant metastases, eligible only for palliative resection; (5) pregnant and lactating women; (6) patients who underwent emergency surgery for bleeding, perforation, and intestinal obstruction; and (7) patients with incomplete medical records during the treatment process that affected result evaluation (Figure 1).

The sample size was calculated using the following formula: $n = (Z_{1-\alpha/2}/\delta)2P(1-P)$, with the postoperative development of an anastomotic fistula as the primary outcome index. Based on our clinical experience, the incidence of intestinal fistula (P) in patients after radical colon cancer surgery was approximately 7%. Taking α as 3% and δ as 0.05 (bilateral), and considering a 10% sample attrition rate, the sample size was determined to be $n = 306$ cases. Using a similar approach, the study population included 510 patients. After excluding 22 patients and accounting for loss to follow-up, 488 cases were finally included.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and informed consent was obtained from all patients.

General information questionnaire

The general information questionnaire collected demographic (*e.g.*, sex and age) and clinical data (*e.g.*, occurrence of anastomotic fistula, presence of hypertension and diabetes, site of lesion, type of tissue, type of pathology, TNM stage, surgical approach, presence of lymph node metastasis, presence of adjuvant chemotherapy, postoperative intensive care unit (ICU) stay, operative time, intraoperative bleeding, postoperative time to exhaustion, hospitalization time, preoperative and postoperative levels of carcinoembryonic antigen (CEA), carbohydrate antigen 125 (CA125), albumin (Alb), total protein (TP), hemoglobin (Hb), blood potassium (K), and platelet).

Diagnosis of anastomotic fistula

Anastomotic leak is defined as the drainage of colonic contents through a drain, wound, or abnormal orifice. It is typically diagnosed using computed tomography (CT) scan or surgery. The specific diagnostic methods used were as follows: Limited or diffuse abdominal pain, turbid purulent drainage fluid or presence of gas, liquid, or fecal discharge, abdominal incision with pus, or even fecal-like fluid overflowing from the abdominal cavity. For low rectal anastomotic fistula, it can be detected through rectal examination and presence of generalized fever; elevated C-reactive protein (CRP) levels in routine blood tests; computed tomography examination showing bubbles or inflammatory edema around the anastomosis, blurring of the surrounding fat planes, or suspected abdominal abscesses associated with the intestine; dilute barium enema imaging showing contrast agent leakage or injection of contrast agent through the drainage tube revealing the flow of contrast agent into the intestinal cavity; and endoscopy or re-operation assisting in confirming the diagnosis.

Prognostic assessment of Functional Assessment of Cancer Therapy-Colorectal

The Functional Assessment of Cancer Therapy-Colorectal (FACT-C) questionnaire is a validated and reliable measure of health-related quality of life in patients with colorectal cancer[17]. It consists of five subscales: physical well-being (seven items; score range 0-28), social well-being (seven items; score range 0-28), emotional well-being (six items; score range 0-24), functional well-being (seven items; score range 0-28), and a colorectal cancer subscale (seven items; score range 0-28). The FACT-C questionnaire comprises a total of 34 items with an overall score range of 0-136.

Statistical analysis

The scores obtained for each subscale were entered into a computer for conversion. All the statistical analyses were performed using SPSS version 26 (IBM Corp., Armonk, NY, United States). Measurement data are presented as means and standard deviations, and count data are expressed as frequencies and percentages. Intergroup comparisons were performed using the *t*-test and chi-square test, and binary logistic regression analysis was used to identify independent risk factors for postoperative anastomotic fistula. Multiple linear regression analysis was performed to determine independent risk factors for assessing patient prognosis. Statistical significance was defined as a two-sided *P* value of < 0.05.

RESULTS

Baseline data

Among the 488 patients included in this study, postoperative anastomotic fistulas developed in 38 patients (7.8%). The chi-square test and *t*-test revealed significant differences between patients with and those without postoperative anastomotic fistulas in terms of age, presence of diabetes, TNM stage, surgical method, preoperative radiotherapy, and

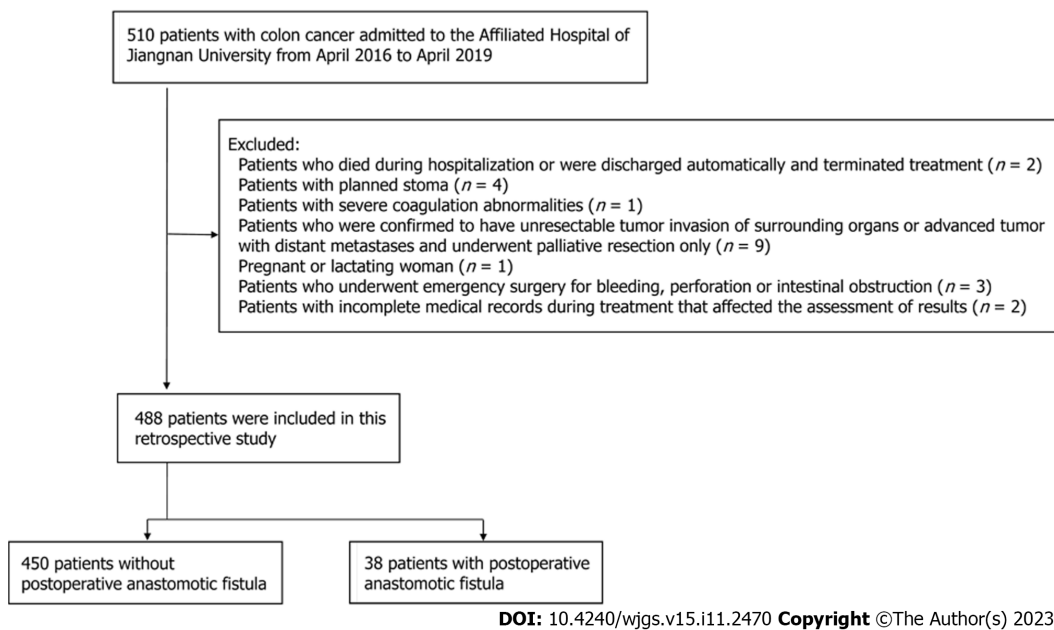


Figure 1 Flow chart illustrating the patient selection process.

postoperative ICU stay ($P < 0.05$). The mean age of patients with postoperative anastomotic fistula was 58.95 ± 11.91 years, and that of patients without fistula was 52.90 ± 12.7 years. Among the patients with and without postoperative anastomotic fistula (38 and 450, respectively), 16 (42.1%) and 110 (24.4%) had diabetes mellitus, 20 (52.6%) and 323 (71.8%) had TNM stage I-II, 9 (23.7%) and 278 (61.8%) underwent laparoscopic radical surgery, and 29 (76.3%) and 172 (38.2%) underwent conventional radical surgery, 13 (34.2%) and 85 (18.9%) received preoperative radiotherapy, and 5 (13.2%) and 20 (4.4%) were transferred to the ICU postoperatively, respectively (Table 1).

Perioperative indicators of patients postoperatively

The *t*-test demonstrated significant differences between patients with and those without postoperative anastomotic fistulas in terms of operative time, intraoperative bleeding, and postoperative hospital stay ($P < 0.05$). The mean operative time, intraoperative bleeding, and postoperative hospital stay for patients with postoperative anastomotic fistula were 187.39 ± 16.31 min, 229.21 ± 60.81 mL, and 11.76 ± 2.57 d, respectively. Patients without fistula had a mean operative time of 179.96 ± 21.32 min, intraoperative bleeding of 187.51 ± 60.51 mL, and postoperative hospital stay of 10.76 ± 2.11 d (Table 2).

Laboratory indicators of patients preoperatively and postoperatively

The *t*-test revealed statistically significant differences between patients with and those without postoperative anastomotic fistulas in terms of preoperative and postoperative Alb, postoperative TP, postoperative Hb, and postoperative K levels ($P < 0.05$). In patients with and without postoperative anastomotic fistula, the preoperative Alb, postoperative Alb, postoperative TP, postoperative Hb, and postoperative K were 33.87 ± 4.74 g/L and 36.22 ± 4.72 g/L, 27.70 ± 3.24 g/L and 29.92 ± 3.56 g/L, 55.32 ± 8.83 g/L and 58.37 ± 8.67 g/L, 115.57 ± 14.00 g/L and 58.37 ± 8.67 g/L, and 4.89 ± 0.49 mmol/L and 4.71 ± 0.47 mmol/L, respectively (Table 3).

Postoperative FACT-C score of patients

The *t*-test demonstrated significant differences in all components of the FACT-C score between patients with and those without postoperative anastomotic fistulas ($P < 0.05$). The mean scores for physical well-being, social well-being, emotional well-being, functional well-being, colorectal cancer subscale, and total scores for patients with postoperative anastomotic fistula were 12.50 ± 3.80 , 18.24 ± 3.77 , 15.50 ± 3.45 , 12.66 ± 3.78 , 15.89 ± 4.59 , and 74.79 ± 11.86 , respectively, and those for patients without fistula were 15.62 ± 3.94 , 20.06 ± 3.54 , 18.32 ± 3.36 , 15.53 ± 4.39 , 19.52 ± 3.98 , and 89.05 ± 13.32 , respectively (Table 4).

Survival and recurrence rates of patients 1-3 years after surgery

The chi-square test revealed that the presence or absence of a postoperative anastomotic fistula significantly influenced the survival rate of patients 1 year after surgery (89.5% vs 96.7%, respectively; $P < 0.05$). However, no significant differences were observed in the 1- to 3-year recurrence and 2- to 3- survival rates between patients with and those without postoperative anastomotic fistulas ($P > 0.05$; Table 5).

Binary logistic regression of patients with postoperative anastomotic fistula

Binary logistic regression analysis identified patient age, TNM stage, surgical procedure, postoperative ICU stay after

Table 1 Comparison of clinical features of patients after radical colon cancer surgery

Item, n (%)	Anastomotic fistula group	Non-anastomotic fistula group	t/χ^2	P value
Gender				
Male	19 (50.0)	236 (52.4)	0.084	0.772
Female	19 (50.0)	214 (47.6)		
Age (yr)	58.95 ± 11.91	52.90 ± 12.7	-2.921	0.004
Hypertension or not				
Yes	17 (44.7)	171 (38.0)	0.672	0.413
No	21 (55.3)	279 (62.0)		
Diabetes or not				
Yes	16 (42.1)	110 (24.4)	5.706	0.017
No	22 (57.9)	340 (75.6)		
Site of lesion				
Left hemi-colon	17 (44.7)	227 (50.4)	0.892	0.640
Right hemi-colon	15 (39.5)	144 (25.3)		
Transverse colon	6 (15.8)	79 (17.6)		
Type of organization				
Low to moderately differentiated adenocarcinoma	27 (71.1)	325 (72.2)	0.024	0.877
Highly differentiated adenocarcinoma	11 (28.9)	125 (27.8)		
Type of TNM				
Type of I-II	20 (52.6)	323 (71.8)	6.151	0.013
Type of III	18 (47.4)	127 (28.2)		
Surgery method				
Laparoscopic radical surgery	9 (23.7)	278 (61.8)	20.991	0.000
Traditional radical surgery	29 (76.3)	172 (38.2)		
Lymph node metastasis or not				
Yes	11 (28.9)	122 (27.1)	0.060	0.807
No	27 (71.1)	328 (72.9)		
With preoperative adjuvant chemotherapy or not				
Yes	13 (34.2)	85 (18.9)	5.125	0.024
No	25 (65.8)	365 (81.1)		
Post-operative ICU stay				
Yes	5 (13.2)	20 (4.4)	5.474	0.019
No	33 (86.8)	430 (95.6)		
Type of pathology				
Ductal gland	30 (78.9)	332 (73.8)	0.489	0.484
Mucus gland	8 (21.1)	118 (26.2)		

TNM: Tumor node metastasis; ICU: Intensive care unit.

surgery, and postoperative Alb, Hb, and potassium levels as independent risk factors for postoperative anastomotic fistulas ($P < 0.05$; Table 6, Figure 2).

Linear regression of FACT-C of anastomotic fistula after radical colon cancer surgery

Multiple linear regression analysis revealed that postoperative anastomotic fistula, advanced age, presence of diabetes, lymph node metastasis, pathological mucinous glands, high postoperative CEA and CA125 Levels, and high preoperative

Table 2 Comparison of perioperative patients after radical colon cancer surgery

Item (mean ± SD)	Operating time (min)	Intraoperative bleeding (mL)	Post-operative time to exhaustion (d)	Postoperative hospitalization time (d)
Anastomotic fistula group	187.39 ± 16.31	229.21 ± 60.81	2.37 ± 0.91	11.76 ± 2.57
Non-anastomotic fistula group	179.96 ± 21.32	187.51 ± 60.51	2.21 ± 0.90	10.76 ± 2.11
<i>t</i> value	-2.098	-4.078	-1.053	-2.777
<i>P</i> value	0.036	0.000	0.293	0.006

Table 3 Comparison of preoperative and postoperative two groups

Item (mean ± SD)	CEA (ng/mL)	CA125 (U/mL)	Alb (g/L)	TP (g/L)	Hb (g/L)	K (mmol/L)
Preoperative group						
Anastomotic fistula group	7.71 ± 0.77	51.51 ± 10.78	33.87 ± 4.74	69.13 ± 9.31	135.18 ± 15.21	3.96 ± 0.18
Non-anastomotic fistula group	7.74 ± 0.81	52.53 ± 10.54	36.22 ± 4.72	69.77 ± 8.04	133.46 ± 13.64	3.94 ± 0.17
<i>t</i> value	0.240	0.574	2.951	0.465	-0.739	-0.549
<i>P</i> value	0.811	0.567	0.003	0.642	0.460	0.583
Postoperative group						
Anastomotic fistula group	5.12 ± 0.90	39.34 ± 10.00	27.70 ± 3.24	55.32 ± 8.83	115.57 ± 14.00	4.89 ± 0.49
Non-anastomotic fistula group	5.01 ± 0.87	39.93 ± 10.11	29.92 ± 3.56	58.37 ± 8.67	120.90 ± 14.06	4.71 ± 0.47
<i>t</i> value	-0.749	0.344	3.716	2.045	2.246	-2.266
<i>P</i> value	0.454	0.731	0.000	0.047	0.025	0.024

CEA: Carcinoembryonic antigen; CA125: Carbohydrate antigen; Alb: Albumin; TP: Total protein; Hb: Hemoglobin; K: Kalium.

Table 4 Functional Assessment of Cancer Therapy-Colorectal of patients after radical colon cancer surgery in two groups

Item (mean ± SD)	First group			Second group		
	PWB	SWB	EWB	FWB	CCS	Total
Anastomotic fistula group	12.50 ± 3.80	18.24 ± 3.77	15.50 ± 3.45	12.66 ± 3.78	15.89 ± 4.59	74.79 ± 11.86
Non-anastomotic fistula group	15.62 ± 3.94	20.06 ± 3.54	18.32 ± 3.36	15.53 ± 4.39	19.52 ± 3.98	89.05 ± 13.32
<i>t</i> value	4.705	3.024	4.962	3.909	4.724	6.389
<i>P</i> value	0	0.003	0	0	0	0

FACT-C: Functional Assessment of Cancer Therapy-Colorectal cancer; PWB: Physical well-being; SWB: Social well-being; EWB: Emotional well-being; FWB: Functional well-being; CCS: Colorectal cancer subscale.

CA125 Levels independently influenced the postoperative prognosis of the patients ($P < 0.05$; Table 7).

DISCUSSION

Colon cancer is a malignancy that is associated with high global incidence and mortality rates[1]. In 2014, colon cancer accounted for approximately one out of every 10 cancers in China[18]. In the United States, colon cancer is among the top three cancers in terms of incidence and mortality[1]. The treatment of colon cancer involves the implementation of various modalities, which are carefully planned based on factors such as the patient's physical condition, tumor pathology, and invasion scope. Individualized and comprehensive treatment approaches are crucial in achieving efficient outcomes. Radical colon cancer surgery is a common clinical procedure that effectively removes diseased tissue. However, this procedure can lead to complications, such as anastomotic fistula, which significantly affects both the quality of life and survival rate of the patient[19]. Previous studies identified anastomotic fistulas as one of the most

Table 5 Survival and recurrence of patients in 1 year to 3 years after surgery in two groups

Item, n (%)	Recurrence 1 yr after surgery		Recurrence 2 yr after surgery		Recurrence 3 yr after surgery		Survival 1 yr after surgery		Survival 2 yr after surgery		Survival 3 yr after surgery	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Anastomotic fistula group	4 (10.5)	34 (89.5)	6 (15.8)	32 (84.2)	7 (18.4)	31 (81.6)	34 (89.5)	4 (10.5)	32 (84.2)	6 (15.8)	28 (73.7)	10 (26.3)
Non-anastomotic fistula group	22 (4.9)	428 (95.1)	40 (8.9)	410 (91.1)	50 (11.1)	400 (88.9)	435 (96.7)	15 (3.3)	412 (91.6)	38 (8.4)	382 (84.9)	68 (15.1)
<i>t</i> value	2.208		1.954		1.815		4.845		2.304		3.276	
<i>P</i> value	0.137		0.162		0.178		0.028		0.129		0.07	

serious complications of colon surgery, resulting in prolonged hospital stays and increased treatment costs. Consistent with these findings, our study also found that patients with postoperative anastomotic fistula had a significantly longer average hospital stay compared with those without postoperative anastomotic fistula[20]. The incidence of anastomotic fistula after colon cancer surgery varies from 2.7% to 15.9%[21], with reported postoperative fistula-related mortality rates ranging from 0.8% to 27%[22-24]. Early identification of anastomotic fistulas is, therefore, crucial to reduce subsequent adverse events.

In the present study, we observed an incidence of postoperative anastomotic fistula of 7.8%, which is consistent with previous research findings. The incidence rates of anastomotic fistulas after laparoscopic and open surgeries were 5.1% and 11.8%, respectively, with a statistically significant difference between the two approaches. Our binary logistic regression analysis further confirmed that the choice of surgical approach independently influenced the incidence of postoperative anastomotic fistula. This can be attributed to the advantages of laparoscopic surgery, including smaller incisions, reduced risk of postoperative infection, and faster wound healing, compared with open surgery. The use of carbon dioxide pneumoperitoneum and laparoscopic magnification provides a clearer intraoperative field of view, allowing for more precise tumor localization and avoidance of important structures, such as the blood vessels and nerves. These factors contribute to a lower risk of postoperative anastomotic fistula[25]. Additionally, our binary logistic regression analysis identified patient age, TNM stage, postoperative stay in the ICU, and postoperative Alb, Hb, and K levels as independent risk factors for postoperative anastomotic fistula. Increasing age has been recognized as an important risk factor for surgical patients, with a linear increase in the risk of postoperative complications among patients aged 18 to 69 years and a nearly 10-fold increase in those aged 70 years and older. A consensus exists among domestic and international scholars that surgical tolerance decreases as patients age, leading to increased procedural uncontrollability. The elderly body gradually experiences a decline in the ability to absorb nutrients and perform metabolic functions, resulting in difficulties absorbing the essential nutrients necessary for postsurgical recovery. This difficulty in healing wounds can contribute to the development of anastomotic fistulas. TNM stage serves as an important index for assessing the severity of colon cancer. Higher TNM stages indicate more severe tumor infiltration, invasion of surrounding organs, and a decline in overall body function, indicating a higher risk of postoperative complications[26]. Research has shown that, during the recovery process after radical colorectal surgery, cells require a significant amount of oxygen and nutrients for adequate energy production. Serum Alb, which is associated with protein synthesis and plasma osmolality, is widely used in clinical practice to assess the nutritional level of patients. A lower postoperative Alb level is indicative of poorer nutritional status[27]. Amino acids and proteins play an important role in wound scar stabilization during the remodeling phase[28]. In patients with colon cancer, who often experience chronic wasting, surgical trauma, perioperative fasting, and significant fluid dilution through intravenous rehydration, the postoperative serum Alb level is

Table 6 Binary Logistics regression of anastomotic after radical colon cancer surgery

Related factor	B	SE	Wald	P value	OR	95%CI	
						Upper	Lower
Surgery method	-2.304	0.878	6.890	0.009	0.100	0.558	0.018
Age (yr)	0.042	0.017	5.882	0.015	1.043	1.079	1.008
Diabetes	0.602	0.413	2.127	0.145	1.827	4.105	0.813
Type of TNM	0.849	0.415	4.187	0.041	2.337	5.268	1.036
Preoperative adjuvant chemotherapy	0.687	0.457	2.261	0.133	1.987	4.865	0.812
Post-operative ICU stay	1.348	0.664	4.124	0.042	3.850	14.144	1.048
Operating time (min)	-0.015	0.013	1.424	0.233	0.985	1.010	0.960
Intraoperative bleeding (mL)	-0.005	0.006	0.561	0.454	0.995	1.007	0.984
Postoperative hospitalization time (d)	0.160	0.093	2.993	0.084	1.174	1.408	0.979
Preoperative Alb (g/L)	-0.023	0.051	0.210	0.647	0.977	1.080	0.883
Postoperative Alb (g/L)	-0.203	0.078	6.693	0.010	0.817	0.952	0.701
Postoperative TP (g/L)	-0.038	0.025	2.406	0.121	0.963	1.010	0.917
Postoperative Hb (g/L)	-0.030	0.015	4.194	0.041	0.970	0.999	0.943
Postoperative K (mmol/L)	0.960	0.441	4.742	0.029	2.612	6.198	1.101

SE: Standard error; OR: Odds ratio; CI: Confidence interval; TNM: Tumor node metastasis; ICU: Intensive care unit; Alb: Albumin; Hb: Hemoglobin; K: Kalium.

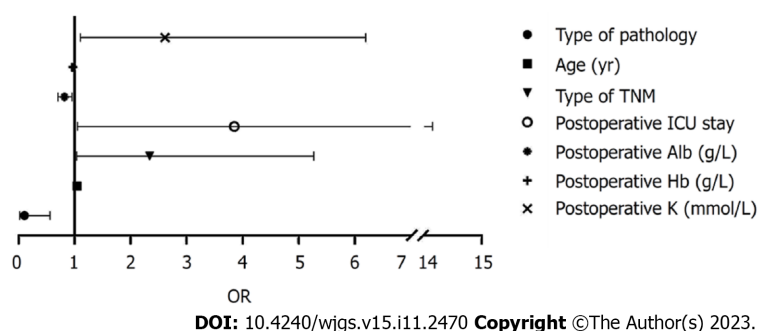


Figure 2 Binary logistic regression analysis of anastomotic fistula following radical colon cancer surgery. TNM: Tumor, node, metastasis; ICU: Intensive care unit; Alb: Albumin; Hb: Hemoglobin; K: Potassium; OR: Odds ratio.

further reduced. In the state of low Alb level, surgical wound exudate is increased. Prolonged fluid accumulation, coupled with the postoperative inflammatory state, affects the healing of the surgical wound and anastomosis, consequently increasing the risk of anastomotic fistulas. Therefore, in clinical practice, medical staff needs to have a clear understanding of the indications for surgery and ensure timely supplementation of proteins and energy to reduce the risk of postoperative anastomotic fistulas.

Furthermore, the results of the multiple linear regression analysis in the present study revealed that several factors independently influenced the prognosis of patients postoperatively, including the occurrence of postoperative anastomotic fistula, advanced age, presence of diabetes mellitus, lymph node metastasis, pathological type of the mucinous gland, high postoperative CEA and CA125 Levels, and high preoperative CA125 Levels. The presence of postoperative anastomotic fistula significantly reduced the survival rate of patients at one year postoperatively. Diabetes mellitus, a metabolic disease, can lead to abnormal protein metabolism, water-electrolyte imbalance, acid-base disorders, and abnormal fat metabolism. Uncontrolled or unstable diabetes disrupts glucose metabolism, resulting in insufficient energy supply to tissue cells, weakened biological barrier function, and compromised bactericidal ability of the immune system[29]. Surgical procedures themselves, both mental and physical as well as the effects of anesthetic drugs, can increase blood glucose levels, exacerbating the negative impact on patient prognosis. Studies have demonstrated that patients with tubular adenocarcinoma show the highest cumulative survival rates at 1, 3, and 5 years postoperatively, whereas those with mucinous adenocarcinoma and papillary carcinoma have lower cumulative survival rates at 3 and 5 years postoperatively[30]. Lymph node metastasis and mucinous adenocarcinoma contribute to poorer prognosis due to

Table 7 Linear regression of Functional Assessment of Cancer Therapy–Colorectal anastomotic fistula after radical colon cancer surgery

Related factor	B	SE	t value	P value
Anastomotic fistula	-11.180	2.506	-4.461	0.000
Surgery method	0.060	3.204	0.019	0.985
Age (yr)	-0.148	0.049	-3.012	0.003
Gender	0.221	1.155	0.191	0.848
Hypertension	0.383	1.183	0.323	0.747
Diabetes	-3.292	1.348	-2.443	0.015
Site of lesion	-0.172	0.765	-0.224	0.823
Type of organization	-0.172	1.288	-0.134	0.894
Type of TNM	-2.414	1.322	-1.826	0.069
Lymph node metastasis	-2.694	1.286	-2.094	0.037
Preoperative adjuvant chemotherapy	-0.196	1.511	-0.130	0.897
Post-operative ICU stay	0.480	2.665	0.180	0.857
Type of pathology	-6.303	1.322	-4.768	0.000
Operating time (min)	0.040	0.036	1.116	0.265
Intraoperative bleeding (mL)	-0.014	0.024	-0.572	0.567
Post-operative time to exhaustion (d)	0.731	0.748	0.977	0.329
Postoperative hospitalization time (d)	-0.242	0.270	-0.894	0.372
Preoperative CEA (ng/mL)	0.912	0.709	1.287	0.199
Postoperative CEA (ng/mL)	-1.778	0.782	-2.274	0.023
Preoperative CA125 (U/mL)	0.488	0.170	2.865	0.004
Postoperative CA125 (U/mL)	-0.416	0.178	-2.333	0.020
Preoperative Alb (g/L)	0.077	0.158	0.490	0.624
Postoperative Alb (g/L)	0.381	0.209	1.818	0.070
Preoperative TP (g/L)	0.020	0.178	0.114	0.910
Postoperative TP (g/L)	0.018	0.168	0.108	0.914
Preoperative Hb (g/L)	0.060	0.132	0.455	0.649
Postoperative Hb (g/L)	-0.068	0.131	-0.523	0.601
Preoperative K (mmol/L)	0.244	3.504	0.070	0.945
Postoperative K (mmol/L)	0.437	1.239	0.353	0.724

SE: Standard error; TNM: Tumor node metastasis; ICU: Intensive care unit; CEA: Carcinoembryonic antigen; CA125: Carbohydrate antigen; Alb: Albumin; TP: Total protein; Hb: Hemoglobin; K: Kalium.

their higher malignancy, faster progression, and greater invasiveness.

In conclusion, numerous risk factors contribute to the development of anastomotic fistulas after radical colon cancer surgery. Therefore, healthcare professionals should carefully evaluate the patients' clinical data before surgery. If a high-risk postoperative anastomotic fistula is identified, prompt communication with patients and their families is essential to consider alternative surgical approaches and improve patient prognosis.

This study has two main limitations. First, it is a retrospective cohort study, which may be susceptible to selection bias. Second, it is a single-center clinical study with a relatively small sample size. Future multicenter clinical studies are warranted to validate these findings.

CONCLUSION

Postoperative anastomotic fistula has a significant impact on prognosis and survival rates. Careful consideration of the clinical characteristics and risk factors associated with anastomotic fistula and implementation of individualized preventive measures at an early stage are crucial to reduce its occurrence. In this manner, we can improve patients' prognosis and prolong their life expectancy.

ARTICLE HIGHLIGHTS

Research background

Patients are prone to complications such as anastomotic fistula after radical colon cancer surgery.

Research motivation

Postoperative complications such as anastomotic fistulas have a significant negative impact on patient prognosis.

Research objectives

This study aimed to investigate the risk factors for postoperative anastomotic fistulas and their impact on the prognosis of patients with colon cancer.

Research methods

This retrospective analysis of 488 patients with colon cancer who underwent radical surgery between April 2016 and April 2019 at our research center was summarized, and the risk factors for the development of anastomotic fistula and the impact of anastomotic fistula occurrence on patient prognosis were analyzed.

Research results

A total of 38 (7.8%) of 488 patients who underwent radical surgery for colon cancer had complications of postoperative anastomotic fistula with a mean Functional Assessment of Cancer Therapy-Colorectal score of 74.79 ± 11.86 .

Research conclusions

Based on the results of our study, we present the independent risk factors affecting the development of anastomotic fistulas and the prognosis of patients with colon cancer after radical surgery. The main causes and preventive measures are also described.

Research perspectives

Based on the clinical data comparing patients who developed anastomotic fistulas with those who did not, the factors influencing the development of anastomotic fistulas in patients postoperatively were analyzed, and the prognoses of the two groups of patients were compared.

FOOTNOTES

Author contributions: Wang J designed the study; Li MH contributed to the analysis of the manuscript; all authors were involved in the data collection and writing of this article; and all authors have read and approved the final manuscript.

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Informed consent statement: The authors take full responsibility for the accuracy and integrity of the work. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013), and informed consent was obtained from all patients.

Conflict-of-interest statement: The authors declare no conflicts of interest.

Data sharing statement: No additional data are available.

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