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ORIGINAL ARTICLE

Updates in surgery for colorectal cancer: incidence and risk factors for acute anastomotic leak—a retrospective study

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Abstract

This study aimed to analyze the incidence and risk factors of acute anastomotic leak (AL) in patients with colorectal cancer (CRC) during and after the COVID-19 pandemic. Active COVID-19 was evaluated as a risk factor of acute AL. A retrospective multicenter analysis was performed on 390 patients with CRC between April 2020 and October 2024. Patients were divided into acute AL ($n = 27$) and no acute AL (no AL) ($n = 363$) groups. In the acute AL group, there were 24 (88.8%) men and three (11.2%) women, with a median age of 63 (65–67) years. Twenty-seven patients in both groups had a previous COVID-19 infection and 15 patients (55.5%) who complained of COVID-19 had AL. The incidence of clinical AL was 6.9% (27/390), of which 11.1% (3/27) and 88.9% (24/27) were grade B and C, respectively. 24/27 (88.9%) had free AL with peritonitis requiring surgical re-intervention. Multivariate analysis showed that active COVID-19 infection (OR = 176, 95% CI 14.27–2172.57, $p < 0.001$) and serum albumin level < 3 g/dl (OR = 16.249, 95% CI 1.033–255.544, $p = 0.04$) were associated risk predictors of AL, while the laparoscopic approach (OR = 0.032, 95% CI 0.002–0.434, $p = 0.01$) and splenic flexure mobilization (OR = 0.022, 95% CI 0.003–4.844, $p = 0.02$) were protective. The incidence of AL after CRC surgery did not increase during or after the COVID-19 pandemic. Active COVID-19 and serum albumin levels < 3 g/dl were associated risk factors for AL, while the laparoscopic approach and splenic flexure mobilization were protective.

Keywords Anastomotic leak · Colorectal cancer · COVID-19 · Risk factors

Introduction

Colorectal cancer (CRC) is a common intestinal malignancy. In 2020, nearly two million new CRC cases and one million deaths from CRC were reported worldwide, making CRC the third most common cancer incidence and the second cause of cancer-related mortality [1].

Currently, surgery is the principal treatment for CRC [2]. Advances in surgical techniques and new instruments have enabled surgeons to achieve substantial advances in radical treatment of CRC. Nevertheless, surgical complications are unavoidable, and acute anastomotic leak (AL) is the most feared complication after CRC surgery, with serious effects on morbidity and mortality [3]. The reported acute AL rates in colorectal surgery range from 0.8 to 26% [4–7]. Acute AL leads to severe postoperative complications, including peritonitis, sepsis, need for reoperation or percutaneous

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intervention, prolonged hospitalization, and increased medical costs [5]

At the end of 2019, an outbreak of COVID-19 caused a massive health crisis and was considered a global pandemic by the World Health Organization (WHO) [8]. The COVID-19 pandemic has influenced public health-seeking behavior, as some patients expressed fear of contracting the virus in hospitals, leading to delays or complete deferrals in seeking treatment [9]. Another strategy involves restricting the availability of cancer screening [10]. Moreover, full lockdowns directly postponed elective cancer surgeries [11]. Delays in the diagnosis of CRC are associated with a higher stage of CRC, with increased mortality and morbidity or necessitate emergency admission [12].

The precise etiology of AL remains controversial. The current knowledge suggests that AL is associated with several risk factors [13–18]. Knowledge of the risk factors for AL is important for risk assessment to provide the best treatment options. Currently, there is a lack of information regarding the incidence and risk of postoperative acute AL after CRC surgery with pTI–pTIII in patients with active or previous COVID-19 infection during and after the COVID-19 pandemic. This study assessed the incidence of AL during and after the COVID-19 pandemic. In addition, we analyzed active COVID-19 as a specific risk factor for postoperative acute AL.

Materials and methods

Study and patient eligibility

A retrospective analysis of 390 consecutive histopathologically validated stage I–III CRC (TNM: T1-3, N0-2b, M0) patients, aged ≥ 18 years, with active COVID-19 infection or a previous history of COVID-19 infection at the time of hospital admission, undergoing radical resection of CRC based on a prospectively maintained database from April 2020 to October 2024 were included in the study. A total of 390 patients were divided into anastomotic leak (AL) ($n = 27$) and no anastomotic leak (no AL) ($n = 363$) groups. Figure 1 shows a flowchart of the inclusion and exclusion criteria for study patients.

Site recruitment

The study was conducted in six centers in Egypt, including three academic centers (Zagazig, Al-Azhar, and Suez Canal Universities) and three non-academic centers (Mataryia Teaching Hospital, El Mahala Institute and Alahrar Oncology centre).

Outcome definition and measurement

The outcome measures were clinically evident acute AL incidence during and after the pandemic and active COVID-19 as a risk factor. COVID-19 was confirmed by PCR [19], while a previous COVID-19 infection was a history diagnosis. According to the International Study Group of Rectal Cancer (ISGRC), AL is defined as a defect in the intestinal wall at the anastomotic site that leads to a connection between the intra- and extraluminal compartments. The clinical diagnosis of AL includes increased abdominal pain, tachycardia, fever, tachypnea, ileus, and feculent drainage. ISGRC classifies AL into grades A, B, or C, according to its influence on clinical management [20]. The imaging technique for the identification of acute AL depends on computed tomography (CT) using oral and intravenous (IV) water-soluble contrast media [21]. Acute ALs were treated according to previous guidelines [22]. Tumor staging adhered to the 8th edition of the American Joint Committee on Cancer (AJCC) pathological tumor-node/metastasis (pTNM) classification and staging system for CRC [23]. Rectal tumor location was categorized as upper (distal border of the tumor 10–15 cm from the anal verge), middle (5–10 cm), or lower rectum (≤5 cm) [24]. The tumor size was determined by histological examination. Postoperative morbidity (within 30 days of operation) was assessed using the Clavien–Dindo classification [25]. All patients were managed following the National Comprehensive Cancer Network (NCCN) guidelines for CRC management [26].

Data collection

Patient and anesthesiologist records (electronic and paper) were used to detect the patient-related factors analyzed in this study. These included age, sex, body mass index (BMI), comorbidities, smoking, COVID-19 [active COVID-19 infection or previous history of COVID-19 infection at the time of hospital admission], serum albumin (<3.5 or ≥3.5 g/dl) [27], Carcino-embryonic antigen (CEA) level, tumor (site, size, differentiation, stage), ASA score, and previous abdominal surgery. The surgery-related factors analyzed were time of surgery, onset of surgery (elective or emergent), blood transfusion, laparoscopic or open surgery, operative time, anastomotic time, stapled or hand-sutured anastomosis, and urgent or elective surgery. Postoperative data included hospital stay (days), postoperative complications (CD classification), and postoperative acute anastomotic leaks (incidence, grade, time of AL, and dealing with AL).

Preoperative evaluation and surgical procedures

The multidisciplinary team (MDT) approach has become the standard for perioperative patient care and has been

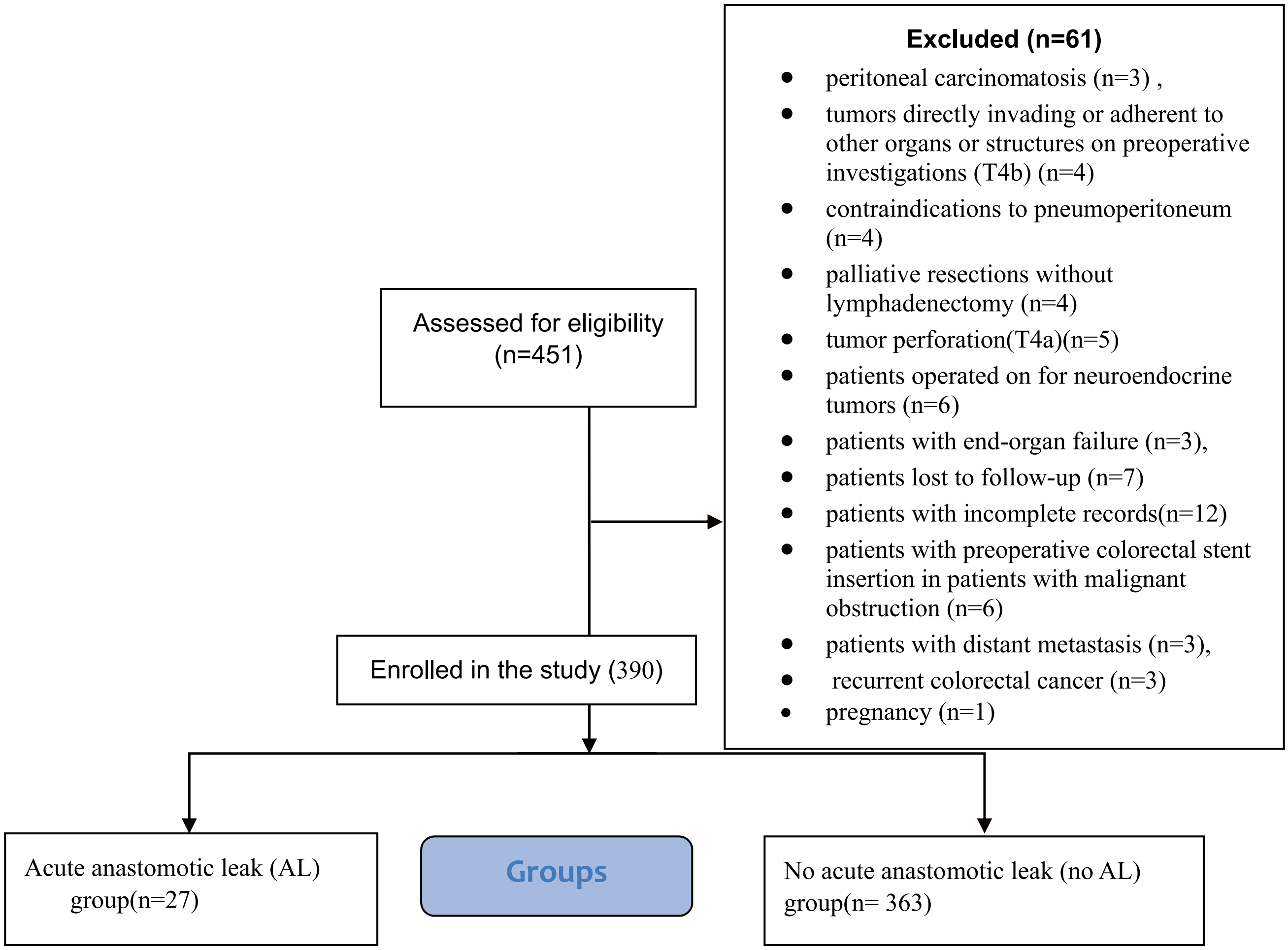

Fig. 1 Flowchart of the inclusion and exclusion criteria for study patients

established for all patients with gastrointestinal cancer undergoing surgery, as previously described [28]. All the patients underwent physical examination, total colonoscopy, pelvi-abdominal computed tomography (CT), carcinoembryonic antigen (CEA) testing, and pelvic magnetic resonance imaging (MRI) for rectal cancer. Every patient received intravenous Cefazolin and Metronidazole prophylaxis before incision. Mechanical bowel preparation is routinely used only for elective left-sided colon and rectal tumors. Experienced surgeons performed all the surgeries. The procedures were performed laparoscopically or via open surgery. Surgical techniques adhered to standardized protocols for laparoscopic/open resection and anastomosis as described in previous literatures [29–31]. One-stage surgery was performed for patients with resectable right-sided CRC. Primary anastomosis was attempted for elective left-sided CRC; otherwise, a stoma was formed based on the patient's condition. The choice between staplers or hand sewing for anastomosis was determined by the surgeon's preference and the anastomosis site. The Hartmann procedure was implemented in patients with left-sided or rectal tumors, but at a high risk of anastomotic dehiscence. Intracorporeal or extracorporeal anastomoses were performed during laparoscopic surgery. Extracorporeal anastomoses in laparoscopy or open approaches were performed using either a stapler or a handsewn.

We performed high ligation of the IMV in all cases of left colon and rectal surgeries. In left-sided tumors, the splenic flexure may be mobilized after ligation of IMV vessels. After mesenteric division, we confirmed the presence of an arterial blood supply to the anastomosis site by palpating the pulse or Doppler. After rectal mobilization for anterior resection, autonomic nerves were preserved. Ileocolic and colo-colic anastomoses were intraperitoneally or extracorporeally achieved using hand-sewn or stapled anastomoses [32]. In anterior resection, the marginal artery and terminal bifurcation of the ascending left colic artery were preserved to ensure adequate blood supply to the descending colon if the marginal artery at the splenic flexure was inadequate. After resection, the anastomosis was checked by hydropneumatic testing through a proctoscope with the anastomosis under irrigation and with the intestine occluded proximal to the anastomosis [33]. The doughnuts were inspected for integrity after stapler retrieval.

Postoperative follow-up

All patients underwent an enhanced recovery program postoperatively according to the previous guideline [34]. The prolonged antibiotic regimen (5 days) was based on institutional protocols for high-risk patients (e.g., hypoalbuminemia, open surgery) to mitigate sepsis risk. AL was diagnosed both clinically and using CT. Patients diagnosed with anastomotic leakage within 30 days of surgery were identified.

Statistical analysis

All analyses were conducted utilizing SPSS software (version 26.0.1.0). Continuous variables are presented as median (IQR) or mean (SD). Continuous variables following a normal distribution were assessed using Student's *t* test, whereas non-normally distributed variables were represented using the Mann–Whitney *U* test. Categorical variables are presented as numbers and percentages and were compared using the chi-square or Fisher's exact test. Variables with a p value < 0.25 in univariate analysis were entered into a multivariate logistic regression model to determine associated predictors of AL, with results reported as odds ratios (ORs) and 95% confidence intervals (CIs). No data were missing for variables included in the final regression model. This analysis identified statistical associations rather than causal relationships. Statistical significance was set at $P < 0.05$.

Results

Patient and tumor characteristics

The demographics, baseline patient characteristics, and tumor characteristics are shown in Table 1. Statistically significant differences were observed between the groups in terms of age ($p = 0.001$), sex ($p = 0.01$), BMI ($p < 0.001$), DM ($p = 0.02$), CHD ($p < 0.001$), smoking ($p < 0.001$), COVID-19 infection ($p < 0.001$), serum albumin ($p < 0.001$), CEA ($p < 0.001$), family history of CRC ($p < 0.001$), tumor differentiation ($p < 0.001$), histology ($p < 0.001$), vascular and perineural invasion ($p < 0.001$), previous abdominal surgery ($p < 0.001$), tumor size ($p = 0.003$), and tumor stage ($p < 0.001$). In the AL group, there were 24 (88.8%) men and 3 (11.2%) women, with a median age of 63 (65–67) years and a median tumor size of 9.35 cm (8.2–9.8). Twenty-seven patients in both groups had a previous COVID-19 infection, and 15 patients (55.5%) who complained of COVID-19 had AL.

Intraoperative data are shown in Table 2

There were no statistically significant differences between the AL and no-AL groups concerning all intraoperative data except the approach (open or laparoscopic) ($p < 0.001$), splenic flexure mobilization ($p = 0.009$), and intraoperative blood transfusion ($p \leq 0.001$). Elective surgeries were performed in 26 (96.3%) and 340 (93.7%) patients in the AL and no-AL groups, respectively. A stoma was performed in 18 patients in the no-AL group, including 14 with ileostomies and four with colostomies. Intraoperative colonic irrigation was not performed in the emergent cases. The open approach was performed mainly in the AL group ($n = 24$, 88.9%), whereas the laparoscopic approach was the main approach in the no-AL group ($n = 308$, 84.8%). Splenic flexure mobilization was performed in 12 (44.4%) and 282 (77.7%) patients, respectively.

Postoperative anastomotic leak and mortality

The incidence of clinical AL was 6.9% (27/390), and the incidence rates of grades B and C AL were 11.1% (3/27) and 88.9% (24/27), respectively. 21/27 (77.8%) patients developed AL within the first 10 days. Twenty-four patients (88.9%) had free AL and peritonitis and required surgical re-intervention. Three patients (11.1%) had AL that required percutaneous drainage, bowel rest, and antibiotics; One patient improved without surgery, while two patients required surgical re-intervention. Overall, 26 patients requiring re-intervention showed intraoperative findings during re-intervention in the form of phlegmon bowel in 7patients(26%) requiring drainage and proximal diversion, minor anastomosis defect (<1 cm) in 14 patients (51.9%) requiring repair of the leak, drainage, and proximal diversion in seven patients; seven patients required resection and anastomosis of the leak site with proximal diversion, and major anastomosis defect (≥1 cm) in five patients (18.5%) requiring resection and anastomosis of the leak site with proximal diversion. Of the 4/390 patients (1%) who died within 30 days after surgery, 2/27 (7.4%) had refractory septic shock after re-intervention in the AL group, and 2/363 (0.6%) had postoperative myocardial infarction in the no AL group (Table 3).

Table 1 Demographics, baseline patient characteristics, and tumour characteristics in the studied groups

	Acute AL (*n* = 27)	No acute AL (*n* = 363)	*P* value
Age, years (median, IQR)	63 (65–67)	56 (52–62)	.001*
Sex			.01*
Male	24 (88.8%)	242 (66.7%)	
Female	3 (11.1%)	121 (33.3%)	
BMI (Mean ± SD)	33.1 ± 2.2	29.8 ± 3.9	<0.001*
DM	9 (33.3%)	58 (16%)	.02*
HTN	9 (33.3%)	83 (22.9%)	.216
CHD	10 (37%)	43 (11.8%)	<0.001*
Smoker	21 (77.8%)	72 (19.8%)	<0.001*
COVID-19 infection (*n* = 27)	15 (55.5%)	12 (3.3%)	<0.001*
Active COVID-19 during index admission	12 (44.4%)	3 (0.8%)	
Past history of COVID-19 infection during index admission	3 (11.1%)	9 (2.5%)	
Serum albumin			<0.001*
<3.5g/dl	18 (66.7%)	23 (6.3%)	
≥3.5g/dl	9 (33.3%)	340 (93.7%)	
CEA			< 0.001*
<50 ng/ml	8 (29.6%)	333 (91.7%)	
>50 ng/ml	19 (70.4%)	30 (8.3%)	
ASA			.372
I	0 (0%)	35 (9.6%)	
II	9 (33.3%)	114 (31.4%)	
III	16 (59.2%)	197 (54.3%)	
IV	2 (7.4%)	17 (4.7%)	
Family history of previous colorectal cancer	12 (44.4%)	20 (5.5%)	< 0.001*
Site of tumor			0.763
Caecum	9 (33.3%)	39 (10.7%)	
Right colon	1 (3.7%)	38 (10.5%)	
Transverse colon	0 (0%)	20 (5.5%)	
Left colon	1 (3.7%)	49 (13.5%)	
Sigmoid	2 (7.4%)	52 (14.3%)	
Hepatic flexure	2 (7.4%)	20 (5.5%)	
Splenic flexure	2 (7.4%)	12 (3.3%)	
Upper rectum ≥ 10–15 cm	1 (3.7%)	74 (20.4%)	
Middle(5–10 cm)–low rectum(≤5 cm)	9 (33.3%)	59 (16.2%)	
Tumor differentiation			<0.001*
Poorly differentiated	25 (92.6%)	33 (9.1%)	
Well-differentiated	0 (0%)	31 (8.5%)	
Moderately differentiated	2 (7.4%)	299 (82.4%)	
Histology			<0.001*
Mucinous	25 (92.6%)	19 (5.2%)	
Adenocarcinoma	2 (7.4%)	344 (94.8%)	
Vascular and perineural invasion	23 (85.2%)	19 (5.2%)	<0.001*
Previous abdominal surgery			<0.001*
Yes	25 (92.6%)	34 (9.4%)	
No	2 (7.4%)	329 (90.6%)	
Size of tumor (cm) (Median, IQR)	9.35 (8.2–9.8)	7.4 (6.3–9.2)	.003*
Stage of tumor			<0.001*
I	0 (0%)	24 (6.6%)	
II	5 (18.5%)	126 (34.7%)	
III	22 (81.5%)	213 (56.7%)	
Neoadjuvant treatment	10	130	.899

CEA: Carcinoembryonic Antigen; ASA: American Society of Anesthesiologists

*Statistically significant

Table 2 Intraoperative data of the studied groups

	Acute AL ($n=27$)	No acute AL ($n=363$)	P value
Onset of surgery			1.00
Elective	26 (96.3%)	340 (93.7%)	
Emergent(obstruction)	1 (3.7%)	23 (6.3%)	
Preoperative colonic preparation			.583
Yes	26 (96.3%)	340 (93.7%)	
No	1 (3.7%)	23 (6.3%)	
Type of surgery			.155
Right hemicolectomy	10 (37%)	77 (21.2%)	
Left hemicolectomy	1 (3.7%)	47 (12.9%)	
Left hemicolectomy with covering proximal ileostomy	0 (0%)	2 (0.6%)	
Transverse colectomy	0 (0%)	19 (5.2%)	
Extended sigmoid colectomy	2 (7.4%)	51 (14%)	
Anterior resection with covering proximal ileostomy	0 (0%)	7 (1.9%)	
Anterior resection	10 (37%)	120 (33.1%)	
Hartmann operation	0 (0%)	4 (1.2%)	
Extended left hemicolectomy	4 (14.8%)	13 (3.6%)	
Extended right hemicolectomy	0 (0%)	18 (5%)	
Transverse colectomy with covering proximal ileostomy	0 (0%)	1 (0.3%)	
Extended left hemicolectomy with covering ileostomy	0 (0%)	1 (0.3%)	
Extended sigmoid colectomy with proximal ileostomy	0 (0%)	3 (0.9%)	
Surgical approach			**<0.001***
Open approach	24 (88.9%)	55 (15.2%)	
Laparoscopic approach	3 (11.1%)	308 (84.8%)	
Splenic flexure mobilization			**.009***
Yes	12 (44.4%)	282 (77.7%)	
No	15 (55.6%)	81 (22.3%)	
Intra or extra corporeal anastomosis in laparoscopic approach			.300
Intracorporeal anastomosis	2 (7.4%)	225 (62%)	
Extracorporeal anastomosis	1 (3.7%)	83 (38%)	
Hand sewen or stapler in open surgery or extracorporeal anastomosis in lap approach			.138
Stapler	13 (48.1)	93 (25.6%)	
Hand sewen	12 (44.4%)	45 (12.4%)	
Operative time(mean, SD)	148.14 ± 18.2	146.06 ± 16.3	.461
Anastomotic time (mean, SD)	25.2 ± 6.8	26.2 ± 5.5	.795
Intraoperative complications			.303
Anastomotic leak	10 (37%)	19 (5.2%)	
Intraoperative bleeding	9 (33.3%)	6 (1.7%)	
Urinary bladder injury	0 (0%)	1 (0.3%)	
Splenic injury	0 (0%)	1 (0.3%)	
Intestinal injury	0 (0%)	1 (0.3%)	
Dealing with intraoperative complications			.447
Suturing of intestinal leak	10 (37%)	9 (2.6%)	
Intestinal reanastomosis of intestinal leak	0 (0%)	10 (2.8%)	
Control the bleeding intraoperatively by ligation of bleeding vessels	9 (33.3%)	6 (1.7%)	
Repair of injury of Urinary bladder	0 (0%)	1 (0.3%)	
Repair of intestinal injury	0 (0%)	1 (0.3%)	
Controlled splenic injury by open splenectomy	0 (0%)	1 (0.3%)	
Intraoperative blood transfusion			**<.001***
Yes	10 (37%)	10 (2.8%)	
No	17 (63%)	353 (79.2%)	

$p < 0.05$ are in bold

*Statistically significant

Table 3 Postoperative data of anastomotic leak in the studied groups

	Acute AL ($n=27$)	No acute AL ($n=363$)	P value
Postoperative hospital stay			
7 days	3 (11.1%)	316 (87.1%)	**<0.001***
>7 days	24 (88.9%)	47 (12.9%)	
CD classification			
Grade 0	0 (0%)	325 (89.5%)	**<0.001***
Grade I	0 (0%)	12 (3.3%)	
Grade II	0 (0%)	5 (1.4%)	
Grade III	20 (74.1%)	19 (5.2%)	
Grade IV	7 (26%)	2 (0.6%)	
Grades of postoperative anastomotic leak			
Grade B leakage	3 (11.1%)	–	
Grade c leakage	24 (88.9%)	–	
Time from surgery to leak			
6th day	2 (7.4%)	–	
7th day	3 (11.1%)	–	
8th day	7 (26%)	–	
9th day	4 (14.8%)	–	
10th day	5 (18.5%)	–	
11th day	2 (7.4%)	–	
12th day	3 (11.1%)	–	
13th day	1 (3.7%)	–	
Forms of leak			
Free leak	24 (88.9%)	–	
Contained leak	3 (11.1%)	–	
Treatment of postoperative leak			
Surgical intervention	24 (88.9%)		
Broad spectrum antibiotic + bowel rest + percutaneous drainage	3 (11.1%)		
Outcomes of radiological drainage of the contained leak			
Improvement	1 (3.7%)	–	
Not improved, requiring surgery	2 (7.4%)	–	
The finding of a leak during the operation			
Phlegmon bowel unable to reach anastomosis	7 (26%)	–	
Minor anastomosis defect(<1 cm)	14 (51.9%)	–	
Major anastomotic defect (≥1 cm)	5 (18.5%)	–	
Dealing with leaks during operation			
Drainage and proximal diversion	7 (26%)	–	
Repair, drainage, and proximal diversion	7 (26%)	–	
Resection of the anastomosis and redo anastomosis with proximal diversion	12 (44.4%)	–	

$p < 0.05$ are in bold

*Statistically significant

Risk factors for postoperative leakage were identified (Table 4)

Multivariate analysis showed that COVID-19 infection (OR = 176, 95% CI 14.27–2172.57, $p<0.001$), serum albumin < 3 g% (OR = 16.249, 95% CI 1.033–255.544, $p=0.04$) were associated risk factors of postoperative AL,

Table 4 Univariate and multivariate logistic regression analyses to predict postoperative acute anastomotic leak

	Univariate		Multivariate	
	OR (95% CI)	*P* value	OR (95% CI)	***P* value**
Age (years)	1.014 (1.014–1.1)	**0.008**	1.113 (0.968–1.280)	0.113
Sex	0.250 (0.074–0.847)	**0.026**	2.760 (0.310–24.575)	0.363
Smoker	14.146 (5.580–36.331)	**<0.001**	3.964 (0.563–27.932)	0.167
Active COVID-19 infection	337 (34.962–2583.32)	**<0.001**	176 (14.27–2172.57)	**< 0.001***
Serum albumin < 3.5 g/dl	0.034 (0.014–0.084)	**<0.001**	16.249 (1.033–255.544)	**0.04***
Emergency surgery	1.759 (0.228–13.546)	0.588	–	**-**
Stage of the tumor	2.9 (1.178–7.559)	**0.02**	4.875 (0.815–19.144)	0.08
Size of the tumor	1.240 (1.029–1.493)	**0.023***	1.121 (0.704–1.787)	0.63
type of surgery	0.992 (0.884–1.114)	0.897	-	**-**
Laparoscopic approach	0.021 (0.006–0.072)	**<0.001**	0.032 (0.002–0.434)	**0.01***
Splenic flexure mobilization	0.359 (0.162–0.798)	**0.012**	0.022 (0.003–4.844)	**0.02***
IMV ligation	0.787 (0.358–1.728)	**0.5**	–	**-**

$p < 0.05$ are in bold

IMV: Inferior mesenteric vessel; OR: Odds ratio; 95% CI: 95% confidence interval

*Significant *P* value

while the laparoscopic approach (OR = 0.032, 95% CI 0.002–0.434, $p = 0.01$) and splenic flexure mobilization (OR = 0.022, 95% CI 0.003–4.844, $p = 0.02$) were protective.

Discussion

This study investigated the updated incidence of acute AL during and after the COVID-19 pandemic, focusing on COVID-19 as a potential risk factor. The incidence of clinically acute AL was 6.9% (27/390), which is consistent with the reported studies between 0.8 and 26% [4–7]. The study incidence of AL was considered the average, and most AL developed within the first 10 days. Notably, 88.9% of the AL cases required surgical re-intervention because of free leaks with peritonitis. COVID-19 and hypoalbuminemia < 3.5 g/dl were independent risk factors for AL, whereas the laparoscopic approach and splenic flexure mobilization were protective factors.

Early identification of risk factors can predict acute AL occurrence, and appropriate measures can be focused on high-risk groups, thereby reducing AL. A previous systematic study showed no differences in AL before and during COVID-19 [35]. However, this study did not evaluate AL after the COVID-19 pandemic. In our multivariate analysis, active COVID-19 was identified as a risk factor for AL.

Several etiologies may explain the relationship between AL and COVID-19. COVID-19 causes a delay in the diagnosis and treatment of CRC, and subsequently, a higher tumor stage and technically complex surgery. In this study, most acute AL patients were stage III. However, our multivariate analysis failed to confirm a significant association between tumor stage and acute AL, probably because of the small sample size of acute AL.

Besides staging, COVID-19 directly damages the epithelial cells lining the GI tract using its spike protein, damaging the surrounding tissues, causing inflammation in the wall, making the intestinal wall unhealthy, and further weakening the anastomosis [36], disrupting various defense systems that protect the GUT wall, including a thick mucus layer [37], colonization resistance conferred by the gut microbiome [38], an epithelial layer with tight junctions, and numerous host factors (immunoglobulin A, proteases, and peptides) with protective functions [39], inhibits beneficial bacteria, namely, Clostridia (butyric acid-producing bacteria in the gut) [40], and releases many pro-inflammatory cytokines that damage the microvascular system and initiate abnormal coagulation system activation. The result will finally be small-vessel vasculitis and extensive microthrombi (microangiopathy) [41]. All of these causes lead to delayed anastomotic healing and a weak intestinal wall to hold sutures or stapler closure of the intestinal anastomosis with subsequent AL. We believe that it is crucial to consider COVID-19 infection as a significant risk factor for AL.

Furthermore, at the beginning of the COVID-19 outbreak, most societies warned about using minimal invasive surgery (MIS) owing to the potential risk of aerosol viral transmission [42]. Laparoscopic surgery was associated with reduced AL rates in this study, likely due to improved visualization, minimal tissue trauma, and reinforcement of the anastomosis, especially in low rectal resection, which supports previous findings [43, 44]. Open surgeries predominated in the AL group, possibly reflecting a selection bias for high-risk cases or pandemic-related shifts in practice. We believe that recent advancements in laparoscopic surgery and standardized surgical techniques have led to better pelvic exposure, which leads to better bowel protection and enables conventional reinforcement of the anastomosis, especially in low rectal resection.

In addition, patients undergoing colorectal surgery are often malnourished. Our data showed that the incidence of acute AL is higher in hypoalbuminemia < 3.5 g/dl and confirmed by multivariate analysis. Hypoalbuminemia causes edema in the intestinal wall, interfering with anastomosis and weakening the anastomosis. This result is consistent with those of previous studies linking malnutrition to impaired wound healing [45]. Significantly decreased albumin levels are common in severe COVID-19 [46]. Hypoalbuminemia is a risk factor for postoperative ileus with bowel distension and tension on the suture [47]. Preoperative maximization of nutrition, preferably enteral nutrition, is important to reduce the risk of malnutrition in malnourished patients.

Furthermore, favorable blood perfusion is a critical factor in anastomotic healing, as ischemia at the anastomotic site has been associated with AL [48]. We believe that COVID-19 is associated with vasculitis, which interferes with the blood supply to the colon [49]. We did not routinely mobilize the splenic flexure during the colorectal cancer surgery. However, our data showed that the incidence of AL in patients with no mobilization of the splenic flexure was, and multivariate data confirmed the protective risk of splenic flexure mobilization against AL development. These findings support the current literature, emphasizing the importance of tension-free anastomoses with optimal perfusion [50]. We recommend mobilization of the splenic flexure during colorectal cancer surgery to induce tension-free anastomosis and to reduce the risk of AL.

Limitations and strengths

This study has certain limitations. This was a retrospective study; therefore, a selection bias was unavoidable. This multicenter trial included centers representative of academic and public hospitals with an excessive overload of COVID-19 patients throughout the outbreak, which enhances generalizability. However, the AL sample in COVID-19 patients was relatively small, which precludes the application of a more robust statistical analysis with enhanced power. Therefore, it is essential to conduct large-scale studies to obtain more representative samples.

Conclusion

Postoperative AL during and after the COVID-19 pandemic did not increase above average. COVID-19 infection and hypoalbuminemia are critical risk factors, whereas laparoscopic approaches and splenic flexure mobilization offer protective benefits. These insights may guide the preoperative risk stratification and surgical planning.

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Declarations

Conflict of interest None.

Consent to participate Consent to participate and publish formal written consent was obtained from patients for publication purposes.

Clinical trial registration This study is registered with ClinicalTrials.gov (NCT06663033).

Ethical approval The Ethics Committee accepted the study protocol (6772024). This study was registered with ClinicalTrials.gov (NCT06663033) and reported following the STROBE reporting guidelines. This study was conducted in compliance with the Declaration of Helsinki.

Patient consent Informed consent for publication of data are present. Any material will be available from the corresponding author when needed.

References

1. Sung H, Ferlay J, Siegel RL, Laversanne M, Soerjomataram I, Jemal A et al (2021) Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 71(3):209–249. https://doi.org/10.3322/caac.21660
2. Nascimbeni R, Di Fabio F, Di Betta E, Salerni B (2009) The changing impact of age on colorectal cancer surgery. A trend analysis. Colorectal Dis 11(1):13–18. https://doi.org/10.1111/j.1463-1318.2008.01491.x
3. Tamura K, Nakamori M, Matsuda K, Hotta T, Nakamura M, Yokoyama S et al (2023) Elective colorectal cancer surgery in nonagenarians and postoperative outcomes. Update Surg 75(4):837–845. https://doi.org/10.1007/s13304-023-01498-4
4. Santoro R, Goglia M, Brighi M, Curci FP, Amodio PM, Giannotti D et al (2024) Exploring 6 years of colorectal cancer surgery in rural Italy: insights from 648 consecutive patients unveiling successes and challenges. Update Surg 76(3):963–974. https://doi.org/10.1007/s13304-024-01829-z

5. Carlini M, Grieco M, Spoletini D, Menditto R, Napoleone V, Brachini G et al (2022) Implementation of the gut microbiota prevents anastomotic leaks in laparoscopic colorectal surgery for cancer:the results of the MIRACLe study. Update Surg 74(4):1253–1262. https://doi.org/10.1007/s13304-022-01305-6
6. Gessler B, Eriksson O, Angenete E (2017) Diagnosis, treatment, and consequences of anastomotic leakage in colorectal surgery. Int J Colorectal Dis 32(4):549–556. https://doi.org/10.1007/s00384-016-2744-x
7. Hain E, Maggiori L, Manceau G, Zappa M, à la Denise JP, Panis Y (2016) Persistent asymptomatic anastomotic leakage after laparoscopic sphincter-saving surgery for rectal cancer: Can diverting stoma be reversed safely at 6 months? Dis Colon Rectum 59(5). https://doi.org/10.1097/DCR.0000000000000568
8. Silverstein WK, Stroud L, Cleghorn GE et al (2020) First imported case of 2019 novel coronavirus in Canada, presenting as mild pneumonia. Lancet 395:734. https://doi.org/10.1016/S0140-6736(20)30370-6
9. Losurdo P, Samardzic N, Di Lenarda F, de Manzini N, Giudici F, Bortul M (2022) The real-word impact of breast and colorectal cancer surgery during the SARS-CoV-2 pandemic. Update Surg 74(3):1063–1072. https://doi.org/10.1007/s13304-021-01212-2
10. Shinkwin M, Silva L, Vogel I, Reeves N, Cornish J, Horwood J et al (2021) COVID-19 and the emergency presentation of colorectal cancer. Colorectal Dis 23(8):2014–2019. https://doi.org/10.1111/codi.15662
11. Glasbey J, Ademuyiwa A, Adisa A et al (2021) Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumor types in 61 countries: an international, prospective, cohort study. Lancet Oncol 22(11):1507–1517. https://doi.org/10.1016/S1470-2045(21)00493-9
12. Suárez J, Mata E, Guerra A, Jiménez G, Montes M, Arias F et al (2021) Impact of the COVID-19 pandemic during Spain's state of emergency on the diagnosis of colorectal cancer. J Surg Oncol 123(1):32–36. https://doi.org/10.1002/jso.26263
13. Liu X-R, Liu F, Zhang W, Peng D (2023) The aortic calcification is a risk factor for colorectal anastomotic leakage. Update Surg 75(7):1857–1865. https://doi.org/10.1007/s13304-023-01630-4
14. Losurdo P, Mastronardi M, de Manzini N, Bortul M (2022) Survival and long-term surgical outcomes after colorectal surgery: are there any gender-related differences? Update Surg 74(4):1337–1343. https://doi.org/10.1007/s13304-022-01323-4
15. Lemke M, Allen L, Samarasinghe N, Vogt K, Brackstone M, Zwiep T (2023) Impact of COVID-19 pandemic on readmission rates following colorectal surgery: a retrospective cohort study. World J Surg 47(9):1. https://doi.org/10.1007/s00268-023-07100-7
16. Yu Z-l, Liu X-h, Liu H-s, Ke J, Zou Y-f, Cao W-t et al (2021) Impact of pelvic dimensions on anastomotic leak after anterior resection for patients with rectal cancer. Surg Endosc 35(5):2134–2143. https://doi.org/10.1007/s00464-020-07617-1
17. Ahmad NZ, Abbas MH, Khan SU, Parvaiz A (2021) A meta-analysis of the role of diverting ileostomy after rectal cancer surgery. Int J Colorectal Dis 36(3):445–455. https://doi.org/10.1007/s00384-020-03771-z
18. Qu H, Liu Y, Bi D-s (2015) Clinical risk factors for anastomotic leakage after laparoscopic anterior resection for rectal cancer: a systematic review and meta-analysis. Surg Endosc 29(12):3608–3617. https://doi.org/10.1007/s00464-015-4117-x
19. Thyagarajan R, Mondy K (2021) Timing of surgery after recovery from coronavirus disease 2019 (COVID-19) infection. Infect Control Hosp Epidemiol 42(6):790–791. https://doi.org/10.1017/ice.2020.325
20. Rahbari NN, Weitz J, Hohenberger W, Heald RJ, Moran B, Ulrich A et al (2010) Definition and grading of anastomotic leakage following anterior resection of the rectum: a proposal by the International Study Group of Rectal Cancer. Surgery 147(3):339–351. https://doi.org/10.1016/j.surg.2009.10.012
21. Hirst NA, Tiernan JP, Millner PA, Jayne DG (2014) Systematic review of methods to predict and detect anastomotic leakage in colorectal surgery. Colorectal Dis 16(2):95–109. https://doi.org/10.1111/codi.12411
22. Saur N, Paulson E (2019) Operative management of anastomotic leaks after colorectal surgery. Clin Colon Rectal Surg 32(03):190–195. https://doi.org/10.1055/s-0038-1677025
23. Amin MB, Greene FL, Edge SB, Compton CC, Gershenwald JE, Brookland RK et al (2017) The Eighth Edition AJCC Cancer Staging Manual: continuing to build a bridge from a population-based to a more "personalized" approach to cancer staging. CA Cancer J Clin 67(2):93–99. https://doi.org/10.3322/caac.21388
24. van der Pas MH, Haglind E, Cuesta MA, Furst A, Lacy AM, Hop WC et al (2013) Laparoscopic versus open surgery for rectal cancer (COLOR II): short-term outcomes of a randomised, phase 3 trial. Lancet Oncol 14(3):210–218. https://doi.org/10.1016/S1470-2045(13)70016-0
25. Dindo D, Demartines N, Clavien P-A (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240(2):205. https://doi.org/10.1097/01.sla.0000133083.54934.ae
26. Benson AB, Venook AP, Adam M, Chang G, Chen Y-J, Ciombor KK et al (2024) NCCN guidelines® insights: rectal cancer, version 3.2024: featured updates to the NCCN guidelines. J Natl Compr Canc Netw 22(6):366–375. https://doi.org/10.6004/jnccn.2024.0041
27. Moghadamyeghaneh Z, Hwang G, Hanna MH, Phelan MJ, Carmichael JC, Mills SD, Pigazzi A, Dolich MO, Stamos MJ (2015) Even modest hypoalbuminemia affects outcomes of colorectal surgery patients. Am J Surg 210:276–284. https://doi.org/10.1016/j.amjsurg.2014.12.038
28. Kuwabara S, Ishido K, Aoki Y, Yamamoto K, Shoji Y, Ichimura T et al (2024) Clinical impact of multidisciplinary team management on postoperative short-term outcomes in colorectral cancer surgery. Update Surg 76(8):2777–2785. https://doi.org/10.1007/s13304-024-02032-w
29. Habeeb T, Mohammad H, Wasefy T, Mansour MI (2023) Outcomes of side-to-end versus end-to-end colorectal anastomosis in nonemergent sigmoid and rectal cancers: a randomized controlled clinical trial. Ann Coloproctol 39(3):231–241. https://doi.org/10.3393/ac.2021.00906.0129
30. Kim NK, Sugihara K, Liang J (2018) Surgical treatment of colorectal cancer. https://doi.org/10.1007/978-981-10-5143-2
31. Mike M (2017) Laparoscopic colorectal cancer surgery. https://doi.org/10.1007/978-981-10-2320-0
32. Shekarriz H, Eigenwald J, Shekarriz B, Upadhyay J, Shekarriz J, Zoubie D et al (2015) Anastomotic leak in colorectal surgery: are 75 % preventable? Int J Colorectal Dis 30(11):1525–1531. https://doi.org/10.1007/s00384-015-2338-z
33. Ricciardi R, Roberts PL, Marcello PW, Hall JF, Read TE, Schoetz DJ (2009) Anastomotic leak testing after colorectal resection: what are the data? Arch Surg 144(5):407–411. https://doi.org/10.1001/archsurg.2009.43
34. Slim N, Teng WH, Shakweh E, Sylvester H-C, Awad M, Schembri R et al (2023) Enhanced recovery programme after colorectal surgery in high-income and low-middle income countries: a systematic review and meta-analysis. Int J Surg. https://doi.org/10.1097/JS9.0000000000000644
35. Zhang D, Yang Y, Hu R-h, Cui X-m, Ma C-y, Yuan B et al (2024) The impact of SARS-Cov-2 Omicron infection on short-term outcomes after elective surgery in patients with gastrointestinal cancer. Update Surg 76(4):1521–1527. https://doi.org/10.1007/s13304-024-01781-y

36. Hoffmann M, Kleine-Weber H, Schroeder S, Krüger N, Herrler T, Erichsen S, Schiergens TS, Herrler G, Wu N-H, Nitsche A, Müller MA, Drosten C, Pöhlmann S (2020) SARS-CoV-2 cell entry depends on ACE2 and TMPRSS2 and is blocked by a clinically proven protease inhibitor. Cell 181:271-280.e8. https://doi.org/10.1016/j.cell.2020.02.052
37. Linden SK, Sutton P, Karlsson NG, Korolik V, McGuckin MA (2008) Mucins in the mucosal barrier to infection. Mucosal Immunol 1(3):183–197. https://doi.org/10.1038/mi.2008.5
38. Buffie CG, Pamer EG (2013) Microbiota-mediated colonization resistance against intestinal pathogens. Nat Rev Immunol 13(11):790–801. https://doi.org/10.1038/nri3535
39. Lawley TD, Walker AW (2013) Intestinal colonization resistance. Immunology 138(1):1–11. https://doi.org/10.1111/j.1365-2567.2012.03616.x
40. Duncan Sylvia H, Barcenilla A, Stewart Colin S, Pryde Susan E, Flint Harry J (2002) Acetate utilization and butyryl coenzyme A (CoA): acetate-CoA transferase in butyrate-producing bacteria from the human large intestine. Appl Environ Microbiol 68(10):5186–5190. https://doi.org/10.1128/AEM.68.10.5186-5190.2002
41. Zeinalpour A, Abbasi M, Shams F, Gholizadeh B (2021) Unusual anastomotic failure in patients with COVID-19: a case report of 2 patients. Arch Clin Infect Dis 16(4):e110032. https://doi.org/10.5812/archcid.110032
42. Society of American Gastrointestinal and Endoscopic Surgeons (SAGES), European Association for Endoscopic Surgery (EAES). Updated intercollegiate general surgery guidance on COVID-19. 2020. Available from: https://www.sages.org/recommendations-surgical-response-covid-19/
43. Shen Z, Zhu X, Ruan H, Shen J, Zhu M, Huang S (2024) Comparison of short-term outcomes of laparoscopic surgery, robot-assisted laparoscopic surgery, and open surgery for lateral lymph-node dissection for rectal cancer: a network meta-analysis. Updat Surg 76(4):1151–1160. https://doi.org/10.1007/s13304-024-01871-x
44. Bissolati M, Orsenigo E, Staudacher C (2016) Minimally invasive approach to colorectal cancer: an evidence-based analysis. Update Surg 68(1):37–46. https://doi.org/10.1007/s13304-016-0350-7
45. Lai C-C, You J-F, Yeh C-Y, Chen J-S, Tang R, Wang J-Y et al (2011) Low preoperative serum albumin in colon cancer: a risk factor for poor outcome. Int J Colorectal Dis 26(4):473–481. https://doi.org/10.1007/s00384-010-1113-4
46. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z et al (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 395(10229):1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3
47. Xie R, Qiu C, Lai R, Que Z, Lin S, Xu D (2025) The impact of postoperative recurrent postoperative ileus on the prognosis of colorectal cancer: a propensity score matched study. Update Surg. https://doi.org/10.1007/s13304-025-02142-z
48. Rutegård M, Rutegård J (2015) Anastomotic leakage in rectal cancer surgery: the role of blood perfusion. World J Gastrointest Surg 7(11):289–292. https://doi.org/10.4240/wjgs.v7.i11.289
49. Habeeb TAAM, Hussain A, Schlottmann F, Kermansaravi M, Aiolfi A, Matic I et al (2022) Recurrent appendicitis following successful drainage of appendicular abscess in adult without interval appendectomy during COVID-19. Prospective cohort study. Int J Surg 97:106200. https://doi.org/10.1016/j.ijsu.2021.106200
50. Yasuda K, Kawai K, Ishihara S, Murono K, Otani K, Nishikawa T et al (2016) Level of arterial ligation in sigmoid colon and rectal cancer surgery. World J Surg Oncol 14(1):99. https://doi.org/10.1186/s12957-016-0819-3

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