



## ORIGINAL ARTICLE

# Outcomes from elective colorectal cancer surgery during the SARS-CoV-2 pandemic

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## Abstract

**Aim:** This study aimed to describe the change in surgical practice and the impact of SARS-CoV-2 on mortality after surgical resection of colorectal cancer during the initial phases of the SARS-CoV-2 pandemic.

**Method:** This was an international cohort study of patients undergoing elective resection of colon or rectal cancer without preoperative suspicion of SARS-CoV-2. Centres entered data from their first recorded case of COVID-19 until 19 April 2020. The primary outcome was 30-day mortality. Secondary outcomes included anastomotic leak, postoperative SARS-CoV-2 and a comparison with prepandemic European Society of Coloproctology cohort data.

**Results:** From 2073 patients in 40 countries, 1.3% (27/2073) had a defunctioning stoma and 3.0% (63/2073) had an end stoma instead of an anastomosis only. Thirty-day mortality was 1.8% (38/2073), the incidence of postoperative SARS-CoV-2 was 3.8% (78/2073) and the anastomotic leak rate was 4.9% (86/1738). Mortality was lowest in patients without a leak or SARS-CoV-2 (14/1601, 0.9%) and highest in patients with both a leak and SARS-CoV-2 (5/13, 38.5%). Mortality was independently associated with anastomotic leak (adjusted odds ratio 6.01, 95% confidence interval 2.58–14.06), postoperative SARS-CoV-2 (16.90, 7.86–36.38), male sex (2.46, 1.01–5.93), age >70 years (2.87, 1.32–6.20) and advanced cancer stage (3.43, 1.16–10.21). Compared with prepandemic data, there were fewer anastomotic leaks (4.9% versus 7.7%) and an overall shorter length of stay (6 versus 7 days) but higher mortality (1.7% versus 1.1%).

**Conclusion:** Surgeons need to further mitigate against both SARS-CoV-2 and anastomotic leak when offering surgery during current and future COVID-19 waves based on patient, operative and organizational risks.

## KEYWORDS

cancer, colon cancer, COVID-19, pandemic, rectal cancer, SARS-CoV-2, surgery, surgical oncology

## 1 | INTRODUCTION

During the early phases of the COVID-19 pandemic there was uncertainty about the impact of perioperative SARS-CoV-2 on surgical

patients and a growing scarcity of intensive care capacity [1,2]. Guidelines emerged which recommended changing anastomotic practice in favour of forming a defunctioning stoma or end stoma in patients who would have previously only had an anastomosis [3–6].

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The first anticipated benefit was to diminish the severity and volume of postoperative anastomotic leaks during a time when the impact of the novel coronavirus was unknown [7]. The second was to reduce the requirement for intensive care when hospital resources were being redirected to the pandemic response [8]. The third was to reduce complications that lead to increased length of hospital stay, in order to release bed space and minimize the risk of nosocomial infection [9,10].

Subsequent data have confirmed the detrimental effect of perioperative SARS-CoV-2, showing a 51.2% rate of postoperative pulmonary complications and a 30-day mortality rate of 23.8% [11]. Despite outbreaks, cancer surgery must continue in order to prevent an overwhelming number of delayed operations, a possible increase in emergency procedures and a significant decline in population health [12].

The extent of new stoma formation during the first phases of the pandemic and the subsequent patient-related outcomes are unknown. The impact of anastomotic leak and postoperative SARS-CoV-2 infection on mortality are also unknown. This study aimed to fill these knowledge gaps and to produce patient-level outcome data that would inform patient selection and informed consent.

## 2 | METHOD

### 2.1 | Study design

This was a planned specialty analysis of adult patients undergoing elective colonic and rectal cancer resection in a prospective international multicentre cohort study of patients undergoing elective surgery without preoperative suspicion of SARS-CoV-2 [13]. Study approvals for participating hospitals were secured by local principal investigators before entry into the study and data collection. The study protocol was either registered as a clinical audit with institutional review or a research study obtaining ethical committee approval, dependent on local and national requirements. Data were collected online and stored on a secure server running the Research Electronic Data Capture (REDCap) web application [14] based in the University of Birmingham, UK. Any hospital performing elective colon or rectal cancer surgery in countries affected by the COVID-19 pandemic was eligible to participate. Hospitals were required to collect data on consecutive eligible patients from the date of their first recorded case of COVID-19 until 19 April 2020.

### 2.2 | Patients and procedures

All adult patients (aged 18 years and over) who underwent elective colonic or rectal cancer resectional surgery with curative intent were eligible. Palliative operations, including those where the tumour was left *in situ* (e.g. formation of an end stoma without resection or bypass procedures), were excluded. Consecutive eligible patients were identified from multidisciplinary team

### What does this paper add to the literature?

Mortality associated with anastomotic leak and postoperative SARS-CoV-2 during the COVID-19 pandemic was extremely high. A relatively small change in stoma practice was seen. Surgeons need to robustly mitigate against both SARS-CoV-2 and anastomotic leak when offering surgery during future waves of COVID-19, based on patient, operative and organizational factors.

meetings, operating lists and outpatient or telemedicine clinics. The day of surgery was defined as day zero, with patients followed up for 30 days postoperatively using routine follow-up pathways. Patients who had an operation for suspected cancer which was subsequently shown to be a preinvasive lesion after histological examination (e.g. high-grade dysplasia, carcinoma *in situ*) were still included in this study. However, patients who had an operation for a suspected cancer but who had a histologically benign lesion were excluded. Elective surgery was defined as any surgery booked in advance of a planned admission to hospital [15].

Patients who were suspected of having, or confirmed to have, SARS-CoV-2 infection at the time of surgery (through nasopharyngeal swab and quantitative reverse transcription polymerase chain reaction, CT thorax or clinical symptoms consistent with COVID-19) were excluded from these analyses.

### 2.3 | Data variables

Baseline patient characteristics included age, sex and American Society of Anesthesiologists (ASA) physical status classification [16]. Age was collected as deciles of years as a categorical variable. ASA status was analysed as grades 1–2 versus grades 3–5. Disease characteristics included baseline tumour, node, metastases (TNM) stage prior to surgery, or neoadjuvant treatment. The TNM stage was used to calculate the patient's baseline cancer disease stage. Disease stages were grouped for analysis as Stage I or Stage II versus Stage III or Stage IV. For patients with cancers involving the rectum, data on neoadjuvant radiotherapy and the duration of therapy (long-course or short-course radiotherapy) were also analysed. Operative variables collected included the operative procedure performed, if a defunctioning or end stoma was formed, the operative approach (minimally invasive, minimally invasive converted to open, or open), the specialty and grade of the lead surgeon (consultant or trainee, colorectal or general surgeon) and whether a stapled or hand-sewn technique was used for the anastomosis, where applicable. We did not specify the precise nature of minimally invasive surgery as there are many variants, but we know from previous international studies that >95% of minimally invasive operations are laparoscopic [17,18]. For analysis, operative procedures were grouped anatomically into right resection, left resection, rectal resection and total/subtotal/



panproctocolectomy. A full list of operative procedures is included in Table S1 in the Supporting Information.

## 2.4 | Outcomes

The primary outcome measure was mortality within the 30 days following surgery. Secondary outcome measures were anastomotic leak, admission to critical care (including high-dependency areas), postoperative SARS-CoV-2 infection and total length of hospital stay up to 30 days after surgery. Postoperative SARS-CoV-2 infection was defined as a positive swab or CT thorax in line with locally implemented protocols, or a clinical diagnosis of symptoms in keeping with COVID-19 in patients where no swab test or CT scan was available.

## 2.5 | Change in anastomotic practice due to COVID-19

Data were collected on the intraoperative decision on stoma formation. Where patients had a stoma, surgeons were asked if this was their 'normal practice' or a 'change in practice due to COVID-19'. The group with a stoma created as a change in practice were labelled 'COVID-end-stoma' or 'COVID-defunctioning-stoma' for tables and analyses. If the patient had a stoma formed and the surgeon indicated a 'change in practice due to COVID-19', they were asked to list all the reasons that applied to that case for this change (Figure S1).

## 2.6 | Prepandemic data

Prepandemic data on colorectal cancer surgery were obtained from published European Society of Coloproctology (ESCP) 2015 Right Hemicolectomy Audit [19–21] and the 2017 Left Colon, Sigmoid and Rectal Resections Audit [18,22] Data. Data from 5792 patients from 54 countries undergoing segmental resection for a colonic or rectal cancer were used for comparison with the equivalent cohort undergoing surgery during the pandemic. These data provided a contemporaneous and detailed comparison of case selection and outcomes during the pandemic and prepandemic periods. Data were not presented in these studies for total or subtotal colectomy, so no comparison was made with these operation types. TNM staging data were not available from the 2015 Right Hemicolectomy Audit and therefore comparison was not made in that field.

## 2.7 | Statistical analysis

The study was conducted according to guidelines set by the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) statement for observational studies [23]. The chi-square test was used to compare differences in categorical data

apart from when cell sizes were small, when Fisher's exact tests were used. Continuous nonparametric data are presented as medians and interquartile ranges and median differences between groups were compared using the Mann–Whitney *U*-test. Missing data are included in summary tables.

For the primary outcome of 30-day mortality, a multilevel logistic regression was used to evaluate the impact of postoperative SARS-CoV-2 and anastomotic leak on death after surgery, summarized using odds ratios (ORs) with 95% confidence intervals (95% CIs). Country was included in the model as a random effect. The model also included clinically plausible preoperative and intraoperative factors in order to adjust for covariates and reduce the risk of confounding factors (age, sex, ASA grade, disease stage and operation type). Chi-square tests and Fisher's exact tests were used to compare outcomes for those with a COVID-stoma and those without. Similar methods were used to compare pandemic data with published prepandemic data. Analysis was performed using Stata SE version 16.1, (StataCorp, Texas, USA).

## 3 | RESULTS

### 3.1 | Patients and disease characteristics

This analysis included 2073 patients undergoing resection of a colonic or rectal cancer in 270 hospitals from 40 countries (Table S2). Of these patients, 1236 (59.6%) were men (Table 1). Overall, 1420 patients (68.7%) were ASA grades 1–2 and 1288 (62.1%) patients had disease Stage I–II. Of 947 patients who had an operation involving the rectum (including panproctocolectomy), 89 (9.4%) received short-course and 206 (21.8%) received long-course neoadjuvant radiotherapy.

Of the 2073 patients, 785 (37.9%) had an open approach and 1186 (57.2%) had a minimally invasive approach. In 102 (4.9%) minimally invasive surgery was attempted with conversion to an open operation. Of patients who had an anastomosis, 85.6% (1474/1722) had a stapled anastomosis. The lead surgeon in the majority of operations was a colorectal consultant (1522/2060, 73.9%), with a trainee as lead operator in 10.5% of procedures (217/2060).

### 3.2 | Change in anastomosis (COVID-stoma) and outcomes

The overall rate of stoma formation was 34.2% (708/2073), which was more frequent than the rate of 27.2% in the prepandemic era (1573/5792). The change in practice of patients having a COVID-stoma was small: 4.3% (90/2073) of all patients (Table 2). Of patients with a new COVID-stoma, 70% (63/90) had an end stoma, far greater than the prepandemic rate for end stoma formation of 43.6% (686/1573) (Table 5). Colorectal trainees were more likely to be the named lead surgeon when defunctioning COVID-stomas were formed (8.3%, 11/133) when compared with colorectal consultants

**TABLE 1** Patients and disease characteristics stratified by operation

	Right-side resection (n = 724)		Left-side resection (n = 367)		Rectal resection (n = 935)		Total/subtotal panproctocolectomy (n = 47)	
	n	%	n	%	n	%	n	%
Sex								
Female	343	47.4%	135	36.8%	343	36.7%	16	34.0%
Male	381	52.6%	232	63.2%	592	63.3%	31	66.0%
ASA grade								
1–2	454	62.7%	244	66.5%	686	73.4%	36	76.6%
3–5	269	37.2%	123	33.5%	244	26.1%	11	23.4%
Missing	1		0		5		0	
Age (years)								
<50	42	5.8%	25	6.8%	96	10.3%	11	23.4%
50–69	268	36.9%	187	51.0%	495	52.9%	16	34.0%
≥70	414	57.3%	155	42.2%	344	36.8%	20	42.6%
Disease stage								
I–II	512	70.7%	216	71.1%	482	51.5%	33	70.2%
III	181	25.0%	78	21.3%	385	41.2%	9	19.1%
IV	31	4.3%	28	7.6%	68	7.3%	5	10.6%
Neoadjuvant radiotherapy <sup>a</sup>								
Short course					89	9.5%	0	0
Long course					205	21.9%	1	2.9%
None					641	68.6%	33	97.1%
Approach								
Laparoscopic	395	54.6%	231	62.9%	540	57.8%	19	40.4%
Open	298	41.1%	109	29.7%	355	38.0%	24	8.5%
Conversion	31	4.3%	27	7.4%	40	4.3%	4	8.5%
Anastomotic technique								
Stapled	527	77.3%	298	89.2%	619	92.1%	30	88.2%
Hand sewn	155	22.7%	36	10.8%	53	7.9%	4	11.8%
No anastomosis	37		30		255		13	
Missing	5		3		8		0	
Seniority								
Colorectal consultant	488	67.5%	263	71.7%	732	78.3%	38	80.8%
Colorectal trainee	61	8.4%	14	3.8%	55	5.9%	3	6.4%
General surgery consultant	126	17.4%	65	17.7%	124	13.3%	6	12.8%
General surgery trainee	43	6.1%	23	6.3%	18	1.9%	0	0
Missing	5		2		6		0	

Abbreviation: ASA, American Society of Anesthesiologists.

<sup>a</sup>Of patients who had an operation involving the rectum.

(0.9%, 13/1521) and general surgical consultants (0.6%, 2/322) Table 2. This contrasts with the prepandemic era when a colorectal trainee was the named lead surgeon in 4.4% (97/2218) of procedures where a stoma was formed. More COVID-end-stomas were formed in patients undergoing rectal resections, in those who had an open approach to surgery and in those who received either no neoadjuvant therapy or long-course neoadjuvant radiotherapy (Table 2). This is also reflected in an increase in the number of end stoma formations

in rectal resections during the pandemic era (27.3%, 255/935) when compared with the prepandemic era (23.7%, 613/2579) and a decrease of formation of anastomosis without a defunctioning stoma during the pandemic (37.4%, 350/935) compared with prepandemic levels (42.8%, 1103/2579). The proportion of COVID-stomas compared with all stomas is shown in Table S3.

Of all rectal resections, 7.4% (69/935) received a COVID-stoma (Figure 1), representing 76.7% of all COVID-stomas (n = 90). In right

**TABLE 2** Additional number of stomas formed due to COVID-19 in relation to all patients undergoing surgery

	COVID-defunctioning-stoma/ all operations		COVID-end-stoma/all operations	
	n	%	n	%
Overall				
New COVID-stomas	27/2073	1.3%	63/2073	3.0%
Sex				
Female	11/837	1.3%	24/837	3.1%
Male	16/1236	1.3%	39/1236	3.2%
ASA grade				
1-2	23/1420	1.6%	36/1420	2.5%
3-5	4/647	0.6%	26/647	4.0%
Age (years)				
<50	3/174	1.7%	2/174	1.1%
50-69	15/966	1.6%	31/966	3.2%
≥70	9/933	1.0%	30/933	3.2%
Operation				
Right resection	1/724	0.1%	10/724	1.4%
Left resection	2/367	0.5%	7/367	1.9%
Rectal resection	24/935	2.5%	45/935	4.8%
Total/subtotal/ panproctocolectomy	0/47	0	1/47	2.1%
Disease stage				
I-II	11/838	1.3%	31/838	3.4%
III	13/653	2.0%	30/653	4.6%
IV	3/133	2.3%	2/133	1.5%
Neoadjuvant radiotherapy <sup>a</sup>				
Short course	3/89	3.4%	1/89	1.1%
Long course	5/206	2.4%	9/206	4.4%
None	16/674	2.4%	35/674	5.2%
Approach				
Minimally invasive	11/1185	0.9%	18/1185	1.5%
Open	15/786	1.9%	42/786	5.3%
Minimally invasive converted to open	1/102	0.9%	3/102	2.9%
Anastomotic technique <sup>b</sup>				
Stapled	25/1474	1.7%	N/A	N/A
Hand sewn	2/248	0.8%	N/A	N/A
Seniority				
Colorectal consultant	13/1521	0.9%	45/1521	3.0%
Colorectal trainee	11/133	8.3%	3/133	2.3%
General surgery consultant	2/322	0.6%	11/322	3.4%
General surgery trainee	1/84	1.2%	5/84	6.0%

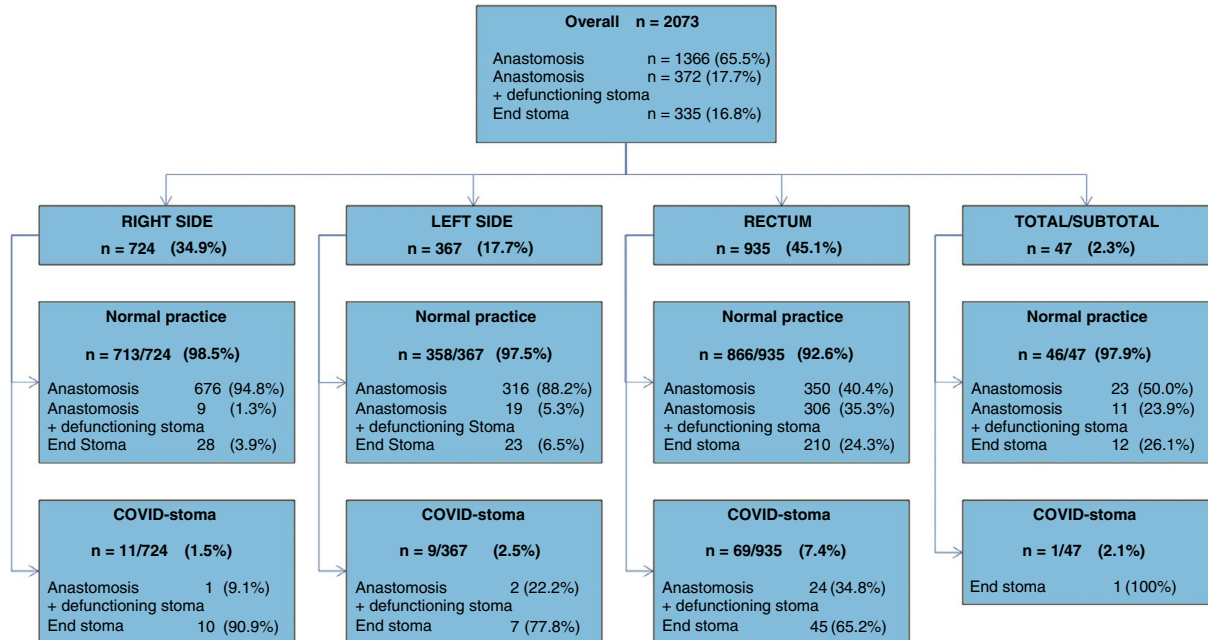
Note: Percentage (%) is the increased number of new stomas (COVID-stoma) formed during the COVID-19 pandemic out of the total number of patients who had an operation in each group.

<sup>a</sup>Of patients who had an operation involving the rectum.

<sup>b</sup>Of patients who had an anastomosis.

colonic resections, 11 COVID-stomas were formed (1.5% of 724 right resections), nine were formed in left colonic resections (2.5% of 367 left resections) and one COVID-stoma was formed from the total/subtotal/panproctocolectomy group (2.1% of 47; Table 2).

There were slight but nonsignificant differences in patients who had a COVID-stoma compared with those who did not (Table 3), including a slight increase in anastomotic leak (7.4% versus 4.9%) and intensive care usage (29.9% versus 22.5%) and slight decrease in



**FIGURE 1** Flowchart of the type of stoma-anastomosis configuration broken down by operative region and if patients had a change in stoma practice due to COVID-19 (COVID-stoma)

**TABLE 3** Outcomes stratified by additional stoma formation due to COVID-19 (COVID-stoma)

	Normal practice		COVID-stoma		P
	n	%	n	%	
<b>Anastomotic leak<sup>a</sup></b>					
No	1627	94.9%	25	92.6%	0.390
Yes	84	4.9%	2	7.4%	
<b>Intensive care</b>					
No	1537	77.5%	64	71.1%	0.157
Yes	446	22.5%	26	29.9%	
<b>Death</b>					
No	1946	98.1%	89	98.9%	1.000
Yes	37	1.9%	1	1.1%	
<b>Postoperative SARS-CoV-2</b>					
No	1909	96.3%	86	95.6%	0.579
Yes	74	3.7%	4	4.4%	
<b>Length of stay (days)<sup>b</sup></b>					
	6 (4–8)		4.5 (4–6.5)		0.270

<sup>a</sup>Of patients who had an anastomosis.

<sup>b</sup>Median (interquartile range).

mortality (1.1% versus 1.9%). There was shorter length of stay in the group with a COVID-stoma (4.5 days versus 6.0 days). Similarly, no difference in outcomes was observed in patients undergoing COVID-stoma when stratified by cancer location (Table S4).

### 3.3 | Reasons for COVID-stoma formation

The reason for change in practice was explored in patients who had a COVID-stoma (stoma formation as a direct result of COVID-19; n = 90). Surgeons were permitted to give more than one reason for change. There was a total of 147 responses. The most common reasons reported for formation of COVID-stoma were 'recommendation from specialty associations' (44%, 64/147; Figure S1) and 'to avoid possible complications requiring critical care' (39%, 57/147). 'Wish to reduce length of inpatient stay' was given in 10% (14/147) and 'fear of patient suffering COVID-19 postoperatively' was given in 6% (9/147) of responses. Only 2% (3/147) cited 'Lack of access to postoperative intensive care' and one cited 'very difficult working conditions of full PPE' as the reasons for COVID-stoma.

### 3.4 | Outcomes after surgery

Overall, 38 (1.8%) patients died within 30 days of surgery, 78 (3.8%) patients developed postoperative SARS-CoV-2 and 86 (4.9%) patients had an anastomotic leak. Mortality rates are presented in Figure 2, and show an increasing relationship with both anastomotic leak and SARS-CoV-2 infection. In risk-adjusted analyses, significant predictors of 30-day mortality were postoperative SARS-CoV-2, anastomotic leak, male sex, age over 70 years, cancer disease Stage IV and having a total/subtotal/panproctocolectomy (see Table 4 for adjusted ORs).

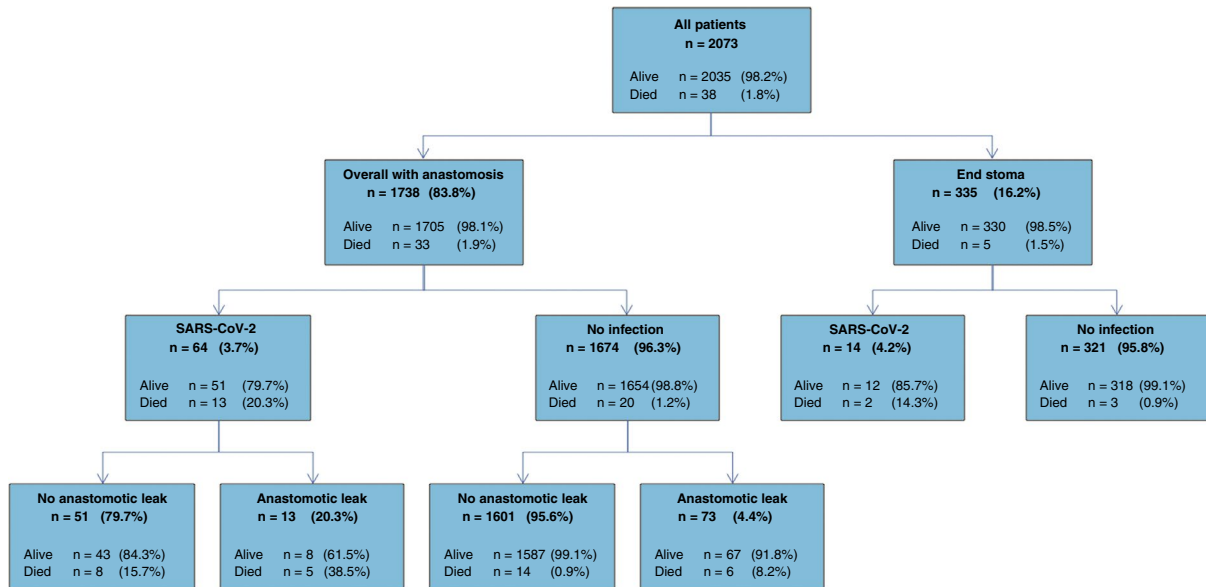


FIGURE 2 Flowchart of mortality related to postoperative SARS-CoV-2 and if an anastomotic leak occurred

### 3.5 | Case selection during the pandemic

Pandemic data are compared with prepandemic data from ESCP-published cohort data in Table 5. There were few differences between patient characteristics across different operations. Overall, during the pandemic, patients selected for surgery were fitter (with lower ASA grade), more stomas were formed and a stapled technique was used more frequently than hand-sewn anastomosis (Table 5). Outcomes following surgery during the pandemic included fewer anastomotic leaks and admissions to critical care; however, mortality was higher during the pandemic than in prepandemic era (Table 5).

In patients who had an anastomotic leak, mortality was 8.6%, (6/70) in the pandemic data. In the prepandemic data, the mortality in those who had a leak was 6.6% (26/395).

## 4 | DISCUSSION

Mortality associated with an anastomotic leak and postoperative SARS-CoV-2 during the first waves of the COVID-19 pandemic was extremely high. A small change in stoma practice was observed, with fewer than 5% of patients receiving a COVID-stoma when they would usually have had an anastomosis only. Although those patients did not suffer any adverse outcomes, those measures alone did not reduce the overall complication rates seen in this study. In comparison with published mortality data following perioperative SARS-CoV-2 infection alone, the relative risk of death was almost 60% higher in combination with anastomotic leak (24.1% versus 34.8%) [11].

Comparison with previous ESCP cohort data identifies some of the selection bias that took place during these phases of the pandemic. There was an increased use of stapled anastomosis, fewer

admissions to intensive care and a shorter length of stay. These all suggest efforts by surgeons and patients to reduce the duration of surgery, resource usage and hospital stay. Rectal cancer patients undergoing surgery seemed to be fitter than in data from the ESCP audits, with a higher proportion of patients of ASA grades 1–2. Slightly fewer patients underwent neoadjuvant therapy compared with before the pandemic, which suggests a greater element of delayed surgery or ‘watch and wait’ strategies during the pandemic. Outcomes from patients who had neoadjuvant therapies and were either delayed or did not have surgery are awaited. There may be an increased flow of patients ‘postpandemic’, both needing surgery and needing monitoring, who will require additional support from already strained surgical systems.

This study had limitations. First, this was an observational study in the first phase of the pandemic, where guideline implementation was incomplete. Data on implementation of guidelines by each hospital or country were not captured in this study. Second, the absolute change in practice presented was small, so firm conclusions cannot be drawn around the safety of the wider adoption of risk-averse practices. Third, comparison with the prepandemic ESCP audit dataset may be biased through undetected patient-, hospital- and country-level differences that could preclude direct comparison, therefore the results must be interpreted with caution and firm conclusions should not be drawn. Fourth, data were not presented for patients who had surgery delayed due to COVID-19 or had an alternative treatment strategy. We therefore present an incomplete picture of the care of colorectal cancer patients during the pandemic. Fifth, change in practice to COVID-stoma was reported by the surgeon and is therefore subjectively reported. We attempted to overcome this by comparing the total stoma rate with prepandemic rates, showing an increased rate of stoma formation during the pandemic. Sixth, despite guidance and concerns around



**TABLE 4** Adjusted and unadjusted regression model of predictors for 30-day mortality

		Mortality		Univariable		Multivariable		P
		n	%	OR	95% CI	OR	95% CI	
Anastomotic leak	No	27/1954	1.4%	–		–		
	Yes	11/93	11.8%	9.21	4.32–19.64	6.01	2.58–14.06	<b>&lt;0.001</b>
SARS-CoV-2	No	23/1995	1.2%	–		–		
	Yes	15/78	19.2%	20.41	10.17–41.00	16.90	7.86–36.38	<b>&lt;0.001</b>
Age (years)	<70	13/1140	1.1%	–		–		
	>70	25/933	2.7%	2.39	1.21–4.69	2.87	1.32–6.20	<b>0.008</b>
Sex	Female	7/837	0.8%	–		–		
	Male	31/1236	2.5%	3.05	1.34–6.96	2.46	1.01–5.93	<b>0.045</b>
ASA grade <sup>a</sup>	1–2	19/1420	1.3%	–		–		
	3–5	19/647	2.9%	2.23	1.17–4.24	1.57	0.76–3.26	0.223
Disease stage	I–II	17/1288	1.3%	–		–		
	III	15/653	2.3%	1.76	0.87–3.54	2.00	0.91–4.20	0.088
	IV	6/132	4.6%	3.56	1.38–9.19	3.43	1.16–10.21	<b>0.026</b>
Operation	Right resection	9/724	1.2%	–		–		
	Left resection	6/367	1.6%	1.32	0.47–3.74	1.45	0.47–4.48	0.524
	Rectal resection	19/935	2.0%	1.65	0.74–3.66	1.60	0.65–3.93	0.302
	Total/subtotal/ panproctocolectomy	4/47	8.5%	7.39	2.19–24.96	9.06	2.21–37.15	<b>0.002</b>

Statistically significant P values are indicated in bold.

<sup>a</sup>American Society of Anesthesiologists (ASA) physical status classification [16].

aerosolization, this study showed that laparoscopic approaches continued. The reasons for this, including surgeon and patient attitudes, deserve further exploration by way of additional qualitative research. Finally, although case selection and more elective stomas can potentially reduce postoperative risks, further robust strategies are needed to mitigate against morbidity and mortality and further exploration is required.

Clear data and safe strategies are needed to continue to provide safe surgery during future pandemic waves. This study highlights several patient, operative and organizational factors that may bring benefit and need further testing. At a patient level, selection of fitter patients, who will benefit most from curative surgery during peaks of pandemics, is logical. This has been previously recommended to both conserve critical care capacity and avoid exposing high-risk patients to nosocomial SARS-CoV-2 transmission [3,9]. At an operative level, the avoidance of leaks seems paramount. Forming stomas alone is not necessarily the solution, as they carry their own risks and morbidity. Selecting lower-risk patients for anastomosis, use of defunctioning stomas and more liberal use of end stomas in high-risk patients might be best supported through formal risk stratification for anastomotic leak [23,24]. At an organizational level, the prevention of postoperative SARS-CoV-2-related infections is paramount. This seems best approached by identifying preoperative, presymptomatic carriers (i.e. preoperative swab testing) and by providing COVID-19-free surgical pathways. Both of these areas require further evidence to best define exactly which measures they include (e.g. number of swabs, role of computed tomography of the

thorax, components of COVID-19-free pathways). With an estimated 3 000 000 cancer operations postponed around the world [12], and more accruing during second waves, efficient measures to safely discharge patients early and protect them from the risk of in-hospital transmission should continue.

## 5 | DATA AVAILABILITY SHARING

Data-sharing requests will be considered by the management group upon written request to the corresponding author. If agreed, de-identified participant data will be available, subject to a data-sharing agreement.

### CONFLICT OF INTEREST

There are no conflicts of interest to declare.

### FUNDING INFORMATION

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**TABLE 5** Comparison of patient and disease characteristics and outcomes of patients undergoing elective cancer operations currently (during the pandemic) alongside composite data from the ESCP 2015 and 2017 audits (prepandemic)

Right	Prepandemic	During pandemic	P-value	Left	Prepandemic	During pandemic	P-value	Rectum	Prepandemic	During pandemic	P-value
Sex				Sex				Sex			
Male	1151 (51.7%)	381 (52.6%)	0.676	Male	589 (59.6%)	232 (63.2%)	0.228	Male	1617 (62.7%)	592 (63.3%)	0.738
Female	1074 (48.3%)	343 (47.4%)		Female	400 (40.4%)	135 (36.8%)		Female	962 (37.3%)	343 (36.7%)	
Age (years)				Age (years)				Age (years)			
<50	104 (4.7%)	42 (5.8%)	0.312	<50	64 (6.5%)	25 (6.8%)	0.434	<50	210 (8.1%)	96 (10.3%)	0.061
50-69	876 (39.3%)	268 (37.0%)		50-69	469 (47.4%)	187 (50.1%)		50-69	1336 (51.8%)	495 (52.9%)	
≥70	1245 (56.0%)	414 (57.2%)		≥70	456 (46.1%)	155 (42.1%)		≥70	1033 (40.1%)	344 (36.8%)	
ASA grade				ASA grade				ASA grade			
1-2	1379 (62.0%)	454 (62.8%)	0.694	1-2	617 (62.7%)	244 (66.5%)	0.198	1-2	1685 (66.0%)	686 (73.8%)	<0.001
3-5	846 (38.0%)	269 (37.2%)		3-5	367 (37.3%)	123 (33.5%)		3-5	868 (34.0%)	244 (26.2%)	
Approach				Disease stage				Disease stage			
Minimally invasive	1211 (54.4%)	395 (54.7%)	<0.001	1-II	468 (50.8%)	261 (71.1%)	<0.001	I-II	1421 (56.8%)	479 (51.5%)	<0.001
Open	813 (36.5%)	298 (41.0%)		III	375 (40.6%)	78 (21.4%)		III	821 (32.8%)	383 (41.2%)	
Conversion	201 (9.1%)	31 (4.3%)		IV	79 (8.6%)	28 (9.6%)		IV	261 (10.4%)	68 (7.3%)	
Operation				Approach				Neoadjuvant radiotherapy			
Anastomosis	2194 (98.6%)	677 (93.5%)	<0.001	Minimally invasive	519 (53.6%)	231 (62.9%)	0.001	Short course	177 (7.2%)	89 (9.5%)	0.001
Anastomosis + defunction	6 (0.3%)	10 (1.4%)		Open	356 (36.8%)	109 (29.7%)		Long course	679 (27.5%)	205 (21.9%)	
End stoma	25 (1.1%)	37 (5.1%)		Conversion	93 (9.6%)	27 (7.4%)		None	1611 (58.1%)	641 (68.6%)	
Anastomotic technique <sup>a</sup>				Operation				Approach			
Stapled	1381 (62.8%)	527 (77.3%)	<0.001	Anastomosis	922 (93.3%)	316 (86.1%)	<0.001	Minimally invasive	1315 (54.2%)	540 (57.8%)	<0.001
Hand sewn	819 (37.2%)	155 (22.7%)		Anastomosis + defunction	18 (1.8%)	21 (5.7%)		Open	867 (35.8%)	355 (38.0%)	
				End stoma	48 (4.9%)	30 (8.2%)		Conversion	243 (10.0%)	40 (4.2%)	

(Continues)

TABLE 5 (Continued)

Right	Prepandemic	During pandemic	P-value	Left	Prepandemic	During pandemic	P-value	Rectum	Prepandemic	During pandemic	P-value
Seniority				Anastomotic technique <sup>a</sup>				Operation			
Colorectal surgeon	1465 (58.3%)	488 (67.9%)	<0.001	Stapled	685 (72.9%)	298 (89.2%)	<0.001	Anastomosis	1103 (42.8%)	350 (37.4%)	0.012
Colorectal trainee	333 (13.2%)	61 (8.5%)		Hand sewn	255 (27.1%)	36 (10.8%)		Anastomosis + defunction	863 (33.5%)	330 (35.3%)	
General surgeon	467 (18.6%)	126 (17.5%)						End stoma	613 (23.7%)	255 (27.3%)	
General surgical trainee	250 (9.9%)	44 (6.1%)									
Anastomotic leak <sup>a</sup>				Seniority				Anastomotic technique <sup>a</sup>			
No	2056 (93.5%)	662 (96.4%)	0.005	Colorectal surgeon	705 (71.3%)	263 (72.1%)	<0.001	Stapled	1811 (92.1%)	619 (92.1%)	0.998
Yes	144 (6.5%)	25 (3.6%)		Colorectal trainee	88 (8.9%)	14 (3.8%)		Hand sewn	155 (7.9%)	53 (7.9%)	
				General surgeon	170 (17.2%)	65 (17.8%)					
				General surgical trainee	26 (2.6%)	23 (6.3%)					
Intensive care				Anastomotic leak <sup>a</sup>				Seniority			
No	1605 (72.1%)	578 (79.8%)	<0.001	No	869 (92.5%)	323 (95.9%)	0.031	Colorectal surgeon	2078 (80.7%)	732 (78.8%)	0.087
Yes	620 (27.9%)	158 (20.2%)		Yes	71 (7.5%)	14 (4.1%)		Colorectal trainee	112 (4.4%)	55 (5.9%)	
								General surgeon	355 (13.8%)	124 (13.4%)	
								General surgical trainee	31 (1.2%)	18 (1.9%)	
Death				Intensive care				Anastomotic leak <sup>a</sup>			
No	2188 (98.3%)	715 (98.8%)	0.155	No	693 (70.1%)	299 (81.5%)	<0.001	No	1786 (90.8%)	636 (93.5%)	0.030
Yes	37 (1.7%)	9 (1.2%)		Yes	295 (29.9%)	68 (18.5%)		Yes	180 (9.2%)	44 (6.5%)	

(Continues)

TABLE 5 (Continued)

Right	During pandemic		Left	During pandemic		P-value	Rectum	During pandemic		P-value
	Prepandemic	During pandemic		Prepandemic	During pandemic			Prepandemic	During pandemic	
Length of stay (days), median (IQR)	7 (5-10)	6 (4-8)	Death			<0.001	Intensive care			
			No	982 (99.3%)	361 (98.4%)	0.254	No	1707 (66.2%)	692 (74.0%)	<0.001
			Yes	7 (0.7%)	6 (1.6%)		Yes	870 (33.8%)	243 (26.0%)	
			Length of stay (days), median (IQR)	7 (5-9)	6 (4-8)	<0.001	Death	2559 (99.2%)	916 (98.0%)	0.261
							Yes	20 (0.8%)	19 (2.0%)	
							Length of stay (days), median (IQR)	8 (6-11)	7 (5-11)	<0.001

Statistically significant P values are indicated in bold.

<sup>a</sup>Of patients who had an anastomosis.

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## SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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## APPENDIX 1

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