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Mortality following postoperative complications after curative-intent colorectal cancer resection: a retrospective UK cohort study

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Mortality following postoperative complications after curative-intent colorectal cancer resection: a retrospective UK cohort study

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Abstract

Purpose

Failure-to-rescue (FTR), mortality among patients who develop a postoperative complication, is an established surgical quality indicator, but many institutional datasets record vital status without the date or cause of death. This study examined mortality following postoperative complications after curative-intent colorectal cancer resection, and the factors associated with it, in a UK cohort.

Methods

A retrospective single-centre cohort of consecutive patients undergoing curative-intent resection for stage I–III colorectal adenocarcinoma between January 2020 and December 2022. The primary outcome was all-cause death during follow-up among patients with a postoperative complication. Patients who died were compared with those who survived, and a prespecified multivariable logistic regression model, constrained by the number of events, was fitted with Firth-corrected sensitivity analyses.

Results

Of 340 patients, 96 (28.2%) developed a postoperative complication, of whom 27 (28.1%) died during follow-up, compared with 42/244 (17.2%) without a complication. Mortality after complication was 52.2% after emergency and 19.4% after elective surgery. Emergency presentation was associated with death after complication (adjusted OR 3.16, 95% CI 1.09–9.19); ASA III–IV showed a borderline association (adjusted OR 2.64, 95% CI 0.97–7.15); operative approach was not independently associated (adjusted OR 1.86, 95% CI 0.66–5.24), and emergency cases were predominantly operated on open. The association with emergency presentation attenuated after further adjustment for age and pT4 stage. Only five deaths were documented during the index admission.

Conclusion

Emergency presentation was the factor most consistently associated with death after postoperative complications, whereas the excess mortality after open surgery largely reflected case mix. Because most deaths occurred beyond the early postoperative period, long-term

mortality after complications should not be equated with conventional FTR; routine recording of the date and cause of death is needed for valid rescue benchmarking.

Keywords Colorectal cancer; failure-to-rescue; postoperative complications; emergency surgery; mortality; surgical quality

Introduction

Surgical resection remains the cornerstone of curative treatment for colorectal cancer, yet postoperative complications continue to affect a substantial proportion of patients despite the widespread adoption of minimally invasive surgery and enhanced recovery pathways. Historically, surgical quality has been assessed using crude complication and mortality rates. Silber and colleagues first proposed that mortality among patients who develop a complication, termed failure-to-rescue (FTR), may better reflect the quality of hospital care than complication rates alone [1].

Subsequent work has supported this concept. In large United States cohorts, hospitals with high and low overall mortality had similar complication rates but differed markedly in their ability to rescue patients once complications occurred [2, 3]. Similar variation has been reported after colorectal cancer surgery in the Dutch Surgical Colorectal Audit, where FTR was approximately three times higher in high-mortality than in low-mortality hospitals [4]. FTR is therefore thought to reflect both patient physiological reserve and institutional factors such as recognition of deterioration, timely escalation, and access to critical care [5–7]. In English colorectal practice, reoperation for complications and subsequent mortality vary between providers [8], and emergency colorectal surgery carries a substantially higher risk of major complications and of FTR than elective surgery [9].

A practical difficulty is that FTR requires the timing of death to be known, conventionally death within 30 or 90 days or during the index admission [2, 4]. Many institutional cancer databases record vital status at follow-up without the date or cause of death. In such datasets, mortality after a complication combines early rescue failure with later deaths from recurrent cancer or comorbidity. Postoperative complications have themselves been associated with reduced long-term survival after colorectal cancer resection [10, 11], so the relationship between complications and later mortality is of interest in its own right, provided it is not mislabelled as early rescue failure.

The aims of this study were therefore to describe mortality following postoperative complications after curative-intent colorectal cancer resection in a contemporary UK cohort, to compare patients who died after a complication with those who survived, and to identify patient and operative factors associated with death after a complication, while being explicit about the limitations imposed by the available outcome data.

Methods

Study design and setting

This retrospective observational cohort study was conducted at a single UK colorectal unit and is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement [12]. Consecutive adult patients undergoing colorectal cancer resection between January 2020 and December 2022 were identified from the institutional cancer registry and cross-checked against pathology reports and electronic patient records.

Eligibility

Patients aged 18 years or over undergoing curative-intent resection of histologically confirmed primary colorectal adenocarcinoma were included. Exclusion criteria were applied on review of registry, multidisciplinary team, pathology and clinical record entries, as follows: benign pathology or a non-colorectal-adenocarcinoma primary (including appendiceal neoplasms and colonic metastases from other primaries); stage IV disease at presentation or documented palliative intent at the index operation; macroscopically incomplete (R2) resection; and missing postoperative complication status or vital status. The derivation of the cohort is shown in Fig. 1.

Definitions

A postoperative complication was defined as any complication following the index resection recorded in the institutional database, which captured the presence of a complication and its principal type. Clavien–Dindo grading [13] and critical care admission were not recorded systematically and could not be derived reliably; reoperation and readmission in patients with a complication were therefore used as markers of complication severity. Emergency surgery was defined as resection during an unplanned acute admission, and elective surgery as resection during a planned admission. Operative approach was classified as laparoscopic, laparoscopic converted to open, or open. Oncological adequacy was defined as an R0 resection with a lymph node yield of at least 12. The preoperative neutrophil-to-lymphocyte ratio (NLR) was calculated from the last preoperative full blood count and dichotomised at 5, a commonly used threshold [14]; physiologically implausible values (neutrophil count above 50×10^9/L or lymphocyte count above 15×10^9/L), which were considered transcription errors, were treated as missing. Mismatch repair (MMR) status was taken from immunohistochemistry reports [15].

Outcomes

The primary outcome was all-cause death during follow-up among patients who developed a postoperative complication, referred to here as mortality after complication. Vital status was

ascertained from the electronic patient record at the time of data extraction in March 2025, giving a potential follow-up of between approximately 26 months (for patients operated on in December 2022) and 62 months (January 2020). The date and cause of death were not available in the institutional dataset. This outcome therefore differs from conventional FTR, which is restricted to deaths within 30 or 90 days of surgery or during the index admission, and we do not treat the two as equivalent. Deaths documented in the clinical record as occurring during the index admission, and their recorded causes, are reported descriptively as a lower bound for conventional in-hospital FTR.

Secondary outcomes were the occurrence of a postoperative complication in the whole cohort, reoperation and readmission, oncological adequacy, recurrence during follow-up, and the association between postoperative complications and all-cause mortality in the whole cohort.

Statistical analysis

Continuous variables are summarised as median and interquartile range (IQR) and compared using the Mann–Whitney U test. Categorical variables are presented as numbers and percentages and compared using the chi-square test, or Fisher's exact test where any expected cell count was below five. Patients with complications who died were compared with those who survived.

The multivariable modelling strategy was prespecified to respect the number of outcome events. With 26 deaths among patients with complete data, the primary model was limited to three candidate predictors, giving approximately nine events per variable [16, 17]. The three predictors were those under evaluation in this study and identified in the FTR literature: emergency presentation, ASA grade III–IV (versus I–II), and open or converted approach (versus laparoscopic). Variables were not selected on the basis of univariable significance. Because the number of events was modest, models were refitted using Firth's penalised likelihood to reduce small-sample bias [18]. Two sensitivity models added age (per 10 years) and then pT4 stage. Multicollinearity was assessed using variance inflation factors; discrimination using the C-statistic; and calibration using the Hosmer–Lemeshow test.

In the whole cohort, two further models were fitted: one estimating the association between a postoperative complication and all-cause mortality, adjusted for age, ASA III–IV, emergency presentation, node-positive disease and pT4 stage (66 events, six variables); and one identifying factors associated with the occurrence of a complication (92 events, five variables). NLR and MMR status were examined in exploratory univariable analyses only, as the number of events did not permit their inclusion in the primary model.

Missing data were infrequent for model variables (at most six patients per variable) and complete-case analysis was used; the extent of missing data for each variable is reported in the tables. MMR status was unavailable for 53 patients (15.6%). Survival analysis was not performed, because dates of death were unavailable. All tests were two-sided with statistical significance at $p < 0.05$. Analyses were performed in Python 3.11 using pandas, NumPy and SciPy, with logistic regression fitted by maximum likelihood and Firth's penalised likelihood.

Ethics

This study used routinely collected clinical data and was undertaken as a service evaluation with institutional clinical governance approval. Data were pseudonymised before analysis. Under UK Health Research Authority guidance, research ethics committee review and individual patient consent were not required.

Results

Cohort characteristics

Of 416 resections identified, 76 were excluded, leaving 340 patients in the study cohort (Fig. 1). Median age was 71.2 (63.9–77.9) years and 198 patients (58.2%) were male. Emergency resection was performed in 58 patients (17.1%). Baseline characteristics according to complication status are shown in Table 1.

A postoperative complication occurred in 96 patients (28.2%), more frequently after emergency than elective surgery (39.7% vs 25.6%). In multivariable analysis of the whole cohort, open or converted approach (OR 2.01 (1.17–3.44), $p = 0.011$) and a rectal primary (OR 2.07 (1.11–3.86), $p = 0.022$) were associated with the occurrence of a complication (Supplementary Table S1).

Complications and their management

The distribution of complication types and associated mortality is shown in Table 2. Postoperative ileus was the most frequent complication, while the highest proportions of deaths followed anastomotic leak (5 of 9) and chest infection or pneumonia (5 of 11). Among patients with a complication, 26/95 underwent reoperation and 34/96 were readmitted.

Mortality after complication

During follow-up, 27 of 96 patients with a complication died (28.1%), compared with 42 of 244 patients without a complication (17.2%; $p = 0.036$). Only 5 deaths (5.2% of patients with a complication) were documented as occurring during the index admission or within approximately one month of surgery. Their recorded causes were postoperative pneumonia (n = 2, including

aspiration pneumonia), anastomotic leak requiring reoperation with subsequent thrombosis (n = 1), death in intensive care without a documented cause (n = 1) and death on postoperative day 2 without a documented cause (n = 1). The remaining deaths could not be dated from the available records.

Patients with a complication who died differed from those who survived (Table 3). They more often had an emergency presentation (46.2% vs 15.9%, p = 0.005), ASA III–IV (59.3% vs 27.9%, p = 0.009) and pT4 disease (55.6% vs 25.0%, p = 0.009), and a longer postoperative stay. They were less likely to have received adjuvant chemotherapy (26.9% vs 59.1%, p = 0.011) and more likely to have developed recurrence (38.5% vs 12.5%, p = 0.012), indicating that a proportion of deaths were cancer-related. Oncological adequacy, preoperative NLR and MMR status did not differ between groups.

Mortality after complication was 52.2% (12/23) after emergency and 19.4% (14/72) after elective surgery (p = 0.005); 45.7% (16/35) in ASA III and 18.3% (11/60) in ASA I–II patients (p = 0.009); no patient with ASA IV developed a complication. By operative approach, mortality after complication was 19.1% (9/47) after laparoscopic, 31.6% (6/19) after converted and 40.0% (12/30) after open surgery (p = 0.130).

Operative approach and confounding by indication

Operative approach was strongly related to urgency. In the whole cohort, 79.3% of emergency resections were open or converted, compared with 31.0% of elective resections. When the analysis was restricted to elective patients with a complication, mortality was 12.5% (5/40) after laparoscopic, 31.6% (6/19) after converted and 23.1% (3/13) after open surgery, with no significant difference between open or converted and laparoscopic approaches (p = 0.172).

Multivariable analysis

In the prespecified primary model (n = 94, 26 deaths), emergency presentation was associated with death after complication (adjusted OR 3.16 (1.09–9.19), p = 0.034). ASA III–IV showed a borderline association (adjusted OR 2.64 (0.97–7.15), p = 0.056), and open or converted approach was not independently associated (adjusted OR 1.86 (0.66–5.24), p = 0.238) (Table 4; Fig. 2). In this model, ASA III–IV and open or converted approach refer to comparisons with ASA I–II and laparoscopic surgery respectively. Estimates were similar with Firth correction. Variance inflation factors were all below 1.11; the C-statistic was 0.74 and the Hosmer–Lemeshow test indicated adequate calibration (p = 0.61).

The association with emergency presentation was sensitive to further adjustment. After adding age, the adjusted OR was 2.63 (0.90–7.72) (p = 0.078), and after adding age and pT4 stage it was 1.92 (0.60–6.13) (p = 0.269) (Table 4). In exploratory univariable analyses, neither NLR ≥5 (OR 1.75 (0.68–4.56), p = 0.248) nor MMR deficiency (OR 0.97 (0.28–3.31), p = 0.960) was associated with death after complication.

In the whole cohort, the crude excess mortality among patients with complications was not independent of patient and tumour factors: after adjustment, a postoperative complication was not significantly associated with death during follow-up (OR 1.37 (0.71–2.61), p = 0.347), whereas age (OR per 10 years 1.86 (1.33–2.59)), emergency presentation (OR 2.10 (1.00–4.37)) and pT4 stage (OR 2.26 (1.16–4.41)) were (Supplementary Table S1).

Discussion

In this cohort of 340 patients undergoing curative-intent colorectal cancer resection, just over one quarter of those who developed a postoperative complication died during follow-up. Emergency presentation was the factor most consistently associated with death after a complication. ASA III–IV showed a borderline association of similar direction, whereas the higher crude mortality after open surgery was largely explained by the predominance of emergency cases operated on open. Only a small number of deaths could be attributed with confidence to the early postoperative period, and the characteristics of patients who died, including lower receipt of adjuvant chemotherapy and higher recurrence, suggest that many later deaths were related to cancer progression or comorbidity rather than to failure of rescue in the conventional sense.

The association between emergency presentation and death after complication is consistent with previous work. In a Finnish population-based cohort, major complications requiring reoperation occurred more than twice as often after emergency colorectal surgery, and FTR was more than three times higher than after elective surgery [9]. Emergency patients commonly present with obstruction, perforation or sepsis, with limited opportunity for preoperative optimisation, and a complication in this context occurs on a background of reduced physiological reserve. Our finding that the association attenuated after adjustment for age and pT4 stage suggests that part of the excess risk reflects the older age and more advanced disease of patients presenting as emergencies. Given the modest number of events, the confidence intervals are wide, and the effect size should be interpreted with caution.

We did not find an independent association between operative approach and death after complication. Laparoscopic resection is preferentially offered to fitter patients with less advanced

disease in the elective setting, whereas emergency resections are predominantly open. In our cohort, almost four in five emergency resections were open or converted, and among elective patients the difference in mortality after complication between approaches was not significant. The unadjusted difference between open and laparoscopic surgery is therefore best explained by confounding by indication, and our data do not support a causal effect of operative approach on the ability to rescue patients from complications.

The crude mortality after complication in this study (28.1%) is considerably higher than conventional FTR rates reported after colorectal surgery, in which mortality is restricted to 30 or 90 days or to the index admission [4, 8]. The principal explanation is that our outcome includes all deaths during follow-up. When the analysis was limited to deaths documented during the index admission, the rate was 5.2%, although this is a minimum estimate because undocumented early deaths cannot be excluded. The two measures answer different questions: conventional FTR reflects the institutional response to acute deterioration [5–7], whereas long-term mortality after complication also captures the oncological consequences of complications and the competing risks of an older, comorbid population. Previous studies have reported that complications, particularly infective complications and anastomotic leak, are associated with reduced long-term survival [10, 11]. In our whole-cohort analysis, the point estimate was in the same direction but not statistically significant after adjustment. Our study was not powered for this comparison, and the wide confidence interval is compatible with the effect sizes previously reported.

Neither the preoperative NLR nor MMR status was associated with death after complication. These analyses were exploratory, with limited power, and the absence of an association should not be taken as evidence of no effect. We report them to avoid selective reporting of the variables collected.

These findings have practical implications. Emergency colorectal cancer patients represent a group at high risk of dying after a complication, supporting efforts to reduce emergency presentation through earlier diagnosis and to ensure that emergency resections are undertaken with senior surgical and anaesthetic input and appropriate postoperative monitoring. Equally important, institutions intending to use FTR for benchmarking need to record the date and cause of death, complication severity, and critical care escalation prospectively, because vital status alone cannot distinguish rescue failure from later cancer-related death.

Strengths and limitations

Strengths of this study include a consecutive, contemporary cohort; explicit and reproducible exclusion criteria with a documented cohort derivation; a prespecified modelling strategy appropriate to the number of events, with penalised-likelihood and sensitivity analyses; and the direct comparison of patients who died after a complication with those who survived.

There are important limitations. First, and most importantly, the date and cause of death were unavailable, so the primary outcome is long-term all-cause mortality after complication rather than conventional FTR, and survival analysis could not be performed. Second, complications were recorded as present or absent with a principal type; Clavien–Dindo grade, critical care admission and time to intervention were not available, so we could not examine rescue processes directly. Third, the number of deaths was modest, limiting the number of variables that could be modelled and producing wide confidence intervals; the association with emergency presentation was not robust to adjustment for age and pT4 stage. Fourth, this was a retrospective single-centre study, and the findings may not be generalisable. Fifth, the study period coincided with the COVID-19 pandemic, which may have affected case mix, stage at presentation and postoperative care. Finally, follow-up duration varied with the date of surgery (approximately 26 to 62 months to data extraction), so patients operated on later had less opportunity to die during follow-up.

Conclusion

In this UK cohort, just over a quarter of patients who developed a complication after curative-intent colorectal cancer resection died during follow-up. Emergency presentation was the factor most consistently associated with death after a complication, although the association was attenuated by age and tumour stage, and the apparent effect of open surgery reflected case mix rather than an independent effect of approach. Most deaths could not be attributed to the early postoperative period, so long-term mortality after complication should not be interpreted as conventional failure-to-rescue. Prospective recording of the date and cause of death, complication severity and escalation of care is needed for valid rescue benchmarking.

Declarations

Funding No external funding was received.

Competing interests The authors declare no competing interests.

Ethics approval Undertaken as a service evaluation with institutional clinical governance approval; research ethics committee approval was not required under UK Health Research Authority guidance.

Consent to participate Not applicable (retrospective analysis of routinely collected, pseudonymised data).

Data availability The pseudonymised dataset is available from the corresponding author on reasonable request, subject to institutional data governance approval.

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Table 1 Characteristics of the study cohort according to postoperative complication status

Characteristic	All (n = 340)	No complication (n = 244)	Complication (n = 96)	p
Age, years, median (IQR)	71.2 (63.9–77.9)	71.2 (63.7–78.1)	71.1 (64.4–77.1)	0.977
Male sex	198/340 (58.2%)	135/244 (55.3%)	63/96 (65.6%)	0.107
ASA III–IV	95/338 (28.1%)	60/243 (24.7%)	35/95 (36.8%)	0.036
Emergency presentation	58/339 (17.1%)	35/244 (14.3%)	23/95 (24.2%)	0.045
Open or converted approach	133/340 (39.1%)	84/244 (34.4%)	49/96 (51.0%)	0.007
Rectal primary	64/340 (18.8%)	41/244 (16.8%)	23/96 (24.0%)	0.172
pT4	78/339 (23.0%)	46/244 (18.9%)	32/95 (33.7%)	0.006
Node-positive (pN+)	137/339 (40.4%)	84/244 (34.4%)	53/95 (55.8%)	<0.001
R1 margin	15/338 (4.4%)	9/242 (3.7%)	6/96 (6.2%)	0.379
Lymph node yield ≥12	307/339 (90.6%)	222/243 (91.4%)	85/96 (88.5%)	0.553
Preoperative NLR, median (IQR)	3.7 (2.4–5.2)	3.7 (2.4–5.1)	3.5 (2.5–5.7)	0.515
Mismatch-repair deficient (dMMR)	50/287 (17.4%)	34/200 (17.0%)	16/87 (18.4%)	0.907
Adjuvant chemotherapy	145/329 (44.1%)	99/237 (41.8%)	46/92 (50.0%)	0.220
Readmission	59/340 (17.4%)	25/244 (10.2%)	34/96 (35.4%)	<0.001
Recurrence during follow-up	53/325 (16.3%)	35/235 (14.9%)	18/90 (20.0%)	0.344
All-cause death during follow-up	69/340 (20.3%)	42/244 (17.2%)	27/96 (28.1%)	0.036

Values are n/N (%) unless stated otherwise; denominators exclude missing values. ASA, American Society of Anesthesiologists grade; NLR, neutrophil-to-lymphocyte ratio; dMMR, mismatch-repair deficient. p values from chi-square or Fisher's exact test, or Mann–Whitney U test for continuous variables.

Table 2 Principal complication type and mortality during follow-up among patients with a postoperative complication

Principal complication	Patients, n	Died during follow-up, n (%)
Postoperative ileus	29	5 (17.2%)
Chest infection / pneumonia	11	5 (45.5%)
Other	10	1 (10.0%)
Surgical site / wound complication	10	1 (10.0%)
Anastomotic leak	9	5 (55.6%)
Small bowel obstruction	8	3 (37.5%)
Complication requiring reoperation (type not specified)	6	2 (33.3%)
Stoma complication	5	2 (40.0%)
Intra-abdominal collection	4	1 (25.0%)
Not recorded	2	2 (100.0%)
Cardiac	1	0 (0.0%)
Bleeding / haematoma	1	0 (0.0%)

Each patient is classified by the principal complication recorded. Percentages are within each complication type and are imprecise for small groups.

Table 3 Comparison of patients with a postoperative complication who died during follow-up and those who survived

Characteristic	All with complication (n = 96)	Survived (n = 69)	Died (n = 27)	p
Age, years, median (IQR)	71.1 (64.4–77.1)	70.4 (62.8–76.6)	73.3 (69.4–80.7)	0.082
Male sex	63/96 (65.6%)	45/69 (65.2%)	18/27 (66.7%)	1.000
ASA III–IV	35/95 (36.8%)	19/68 (27.9%)	16/27 (59.3%)	0.009
Emergency presentation	23/95 (24.2%)	11/69 (15.9%)	12/26 (46.2%)	0.005

Characteristic	All with complication (n = 96)	Survived (n = 69)	Died (n = 27)	p
Perforation	8/96 (8.3%)	7/69 (10.1%)	1/27 (3.7%)	0.435
Open or converted approach	49/96 (51.0%)	31/69 (44.9%)	18/27 (66.7%)	0.091
Rectal primary	23/96 (24.0%)	18/69 (26.1%)	5/27 (18.5%)	0.606
pT4	32/95 (33.7%)	17/68 (25.0%)	15/27 (55.6%)	0.009
Node-positive (pN+)	53/95 (55.8%)	35/68 (51.5%)	18/27 (66.7%)	0.264
R1 margin	6/96 (6.2%)	4/69 (5.8%)	2/27 (7.4%)	1.000
Lymph node yield ≥12	85/96 (88.5%)	61/69 (88.4%)	24/27 (88.9%)	1.000
Oncologically adequate (R0 and ≥12 nodes)	81/96 (84.4%)	59/69 (85.5%)	22/27 (81.5%)	0.755
Preoperative NLR, median (IQR)	3.5 (2.5–5.7)	3.5 (2.5–5.4)	3.7 (2.8–5.7)	0.827
Preoperative NLR ≥5	29/94 (30.9%)	19/69 (27.5%)	10/25 (40.0%)	0.366
dMMR	16/87 (18.4%)	12/64 (18.8%)	4/23 (17.4%)	1.000
Reoperation	26/95 (27.4%)	16/69 (23.2%)	10/26 (38.5%)	0.218
Readmission	34/96 (35.4%)	22/69 (31.9%)	12/27 (44.4%)	0.358
Adjuvant chemotherapy	46/92 (50.0%)	39/66 (59.1%)	7/26 (26.9%)	0.011
Recurrence during follow-up	18/90 (20.0%)	8/64 (12.5%)	10/26 (38.5%)	0.012
Postoperative length of stay, days, median (IQR)	10.0 (7.0–15.8)	9.0 (7.0–14.0)	15.0 (9.0–23.0)	0.029

Values are n/N (%) unless stated otherwise; denominators exclude missing values. Reoperation refers to reoperation in patients with a postoperative complication. Length of stay excludes implausible values (<0 or >200 days), which were considered data-entry errors.

Table 4 Logistic regression analysis of factors associated with death during follow-up among patients with a postoperative complication

Variable	Unadjusted OR (95% CI)	Primary model aOR (95% CI)	p	Primary model, Firth aOR (95% CI)	Sensitivity 1: + age (Firth)	Sensitivity 2: + age, pT4 (Firth)
Emergency presentation	4.52 (1.65–12.35)	3.16 (1.09–9.19)	0.034	3.02 (1.05–8.71)	2.63 (0.90–7.72)	1.92 (0.60–6.13)
ASA III–IV	3.75 (1.48–9.53)	2.64 (0.97–7.15)	0.056	2.54 (0.95–6.80)	2.09 (0.74–5.94)	2.25 (0.78–6.51)
Open/converted approach	2.45 (0.97–6.21)	1.86 (0.66–5.24)	0.238	1.80 (0.65–4.99)	1.81 (0.65–5.05)	1.69 (0.59–4.80)
Age (per 10 years)	1.62 (0.98–2.67)	—		—	1.24 (0.71–2.17)	1.26 (0.71–2.23)
pT4	3.75 (1.47–9.57)	—		—	—	2.08 (0.71–6.12)
Patients / deaths	—	94 / 26		94 / 26	92 / 25	91 / 25
C-statistic	—	0.74		—	0.74	0.77

OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval. The primary model was prespecified with three predictors to maintain approximately nine events per variable. Maximum variance inflation factor 1.11; Hosmer–Lemeshow p = 0.61 for the primary model.

Figure legends

Fig. 1 STROBE flow diagram showing derivation of the study cohort and outcomes among patients with and without a postoperative complication

Fig. 2 Unadjusted and adjusted odds ratios (95% confidence intervals) for death during follow-up among patients with a postoperative complication, from the prespecified primary logistic regression model (n = 94, 26 deaths). The horizontal axis is on a logarithmic scale

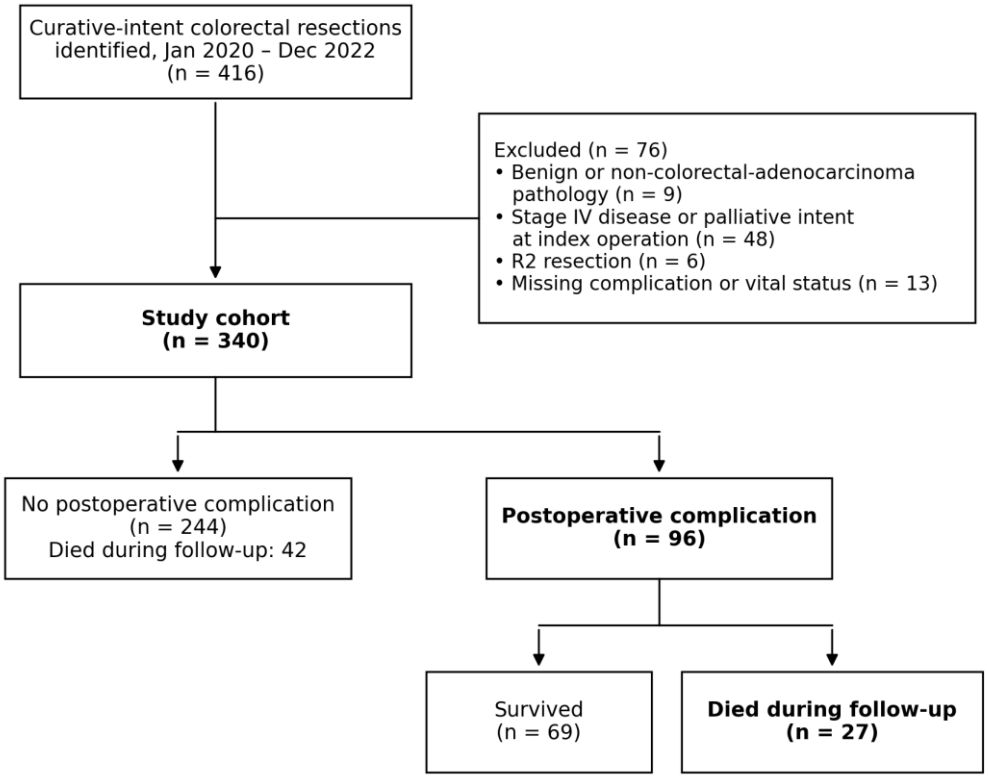


Fig. 1

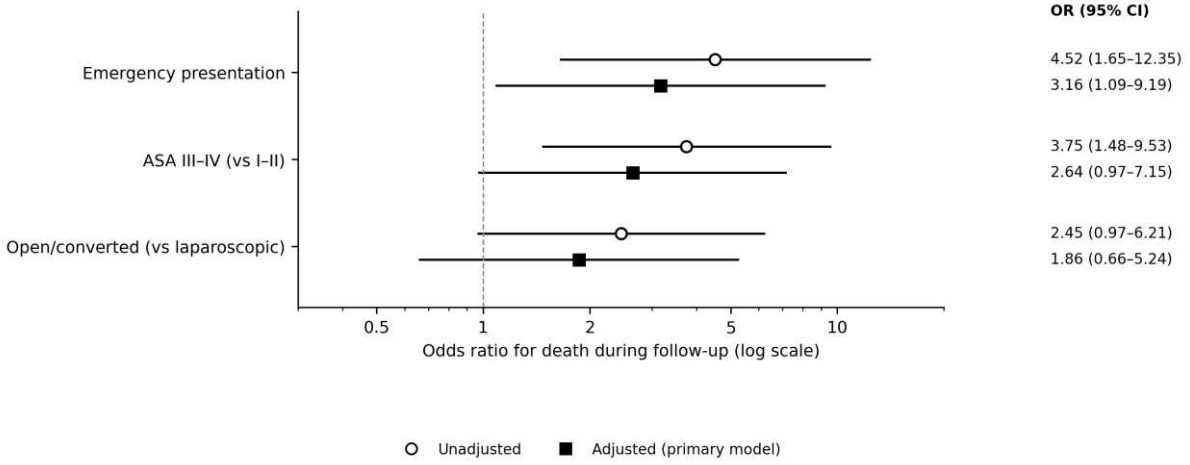


Fig. 2

Supplementary Table S1 Whole-cohort multivariable models

Variable	Adjusted OR (95% CI)	p
A. Death during follow-up (all patients)		
Postoperative complication	1.37 (0.71–2.61)	0.347
Age (per 10 years)	1.86 (1.33–2.59)	<0.001
ASA III–IV (vs I–II)	1.25 (0.65–2.41)	0.500
Emergency presentation	2.10 (1.00–4.37)	0.049
Node-positive disease (pN+)	1.82 (0.99–3.36)	0.055
pT4	2.26 (1.16–4.41)	0.017
Patients / deaths: 330 / 66; C-statistic 0.77		
B. Occurrence of a postoperative complication		
Age (per 10 years)	0.97 (0.87–1.07)	0.528
ASA III–IV (vs I–II)	1.65 (0.96–2.84)	0.071
Emergency presentation	1.42 (0.73–2.76)	0.304
Open/converted approach (vs laparoscopic)	2.01 (1.17–3.44)	0.011
Rectal primary	2.07 (1.11–3.86)	0.022
Patients / complications: 331 / 92; C-statistic 0.65		

Maximum likelihood logistic regression; complete-case analysis. Node-positive disease refers to pathological nodal status (pN1–2).

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- 4SupplementaryTableS1.docx