BJS Open, 2022, zrac153
https://doi.org/10.1093/bjsopen/zrac153
Original Article

Outcomes of emergency surgical interventions in right-sided colonic cancer: nationwide population-based study based on Danish Colorectal Cancer Group register

Alaa El-Hussuna[1,*], Maria Knudsen[2], Matteo Frasson[3] and Laurids Østergaard Poulsen[4]

[1]Department of Surgery, OpenSource Research Collaboration, Aalborg, Denmark
[2]Department of Epidemiology, Aalborg University Hospital, Aalborg, Denmark
[3]Department of General Surgery, La Fe University Hospital, Valencia, Spain
[4]Department of Oncology, Aalborg University Hospital, Aalborg, Denmark

*Correspondence to: Alaa El-Hussuna, Department of Surgery, OpenSourceResearch Collaboration, Engbovej 26, 9200 Aalborg SV, Denmark (e-mail: contact@osrc.network)

Abstract

Aim: The aim of this study was to investigate the trends in morbidity and mortality of patients with right-sided colonic cancer who had an emergency surgical procedure in Denmark after the introduction of quality index parameters.

Methods: This was a retrospective nationwide study based on a prospectively maintained Danish Colorectal Cancer Group database focused on right-sided colonic cancer in the interval from 1 May 2001 to 30 April 2018, who underwent emergency surgical intervention (within 48 h of hospital admission). The primary objective was to investigate the trends in morbidity and mortality throughout the study years. Multivariable estimates were adjusted for age, sex, smoking status, alcohol consumption, ASA score classification, tumour localization, type of access to abdominal cavity, surgeon's grade of specialization, and metastatic disease.

Results: Out of 2839 patients, a total of 2740 patients fulfilled the inclusion criteria, of whom 2464 underwent right or transverse colon resection (89.9 per cent). The 30-day and 90-day postoperative mortality rates were significantly reduced over the time of the study (OR 0.943, 95 per cent c.i. 0.922 to 0.965, $P < 0.001$ and OR 0.953, 95 per cent c.i. 0.934 to 0.972, $P < 0.001$ respectively); however, the complication rates did not follow this trend. Older patients (OR 1.032, 95 per cent c.i. 1.009 to 1.055, $P = 0.005$) and patients with high ASA scores (OR 1.61, 95 per cent c.i. 1.422 to 1.830, $P < 0.001$) had higher rates of severe grade 3b postoperative complications. A stoma was constructed in 276 patients (10 per cent), whereas a stent was used in only eight patients. Defunctioning procedures, including stoma construction or colonic stenting (without oncological resection), did not reduce the risk of complications compared with that of definitive surgery.

Conclusion: The 30-day and 90-day postoperative mortality rates were significantly reduced over the time of the study. Age and ASA score were risk factors for severe postoperative complications.

Introduction

The survival of patients with colonic cancer has been improving during the last two decades. In Denmark, the 5-year overall survival of patients with colonic cancer improved from 49 per cent to 66 per cent, from 1995 to 2014 compared with the increase from 47 per cent to 59 per cent in the UK over the same years[1].

A growing body of evidence supports different outcomes for patients with right-sided colonic cancer (RSCC) compared with those with left-sided colonic cancer (LSCC). Additionally, epidemiology, pathogenesis, and prognosis might differ between patients diagnosed with RSCC and those diagnosed with LSCC[2–4]. These differences might originate from embryology[3,5] and have an impact even on the different rates of urgency of surgical interventions[6]. Emergency surgery, defined as surgery performed due to life-threatening or urgent medical conditions, such as colonic obstruction, perforation, and bleeding[7–10], is usually performed within 48 h of admission[11]. Some studies reported higher rates of postoperative complications and mortality in patients with RSCC who underwent emergency surgical interventions[2,10,12] compared with those who underwent elective surgery. Accordingly, the survival rate might be lower in patients who underwent emergency colonic resections than in patients treated electively, even after adjustment for tumour stage[6,8,10,13].

Between 2010 and 2014, the Danish Colorectal Cancer Group (DCCG) introduced many quality index parameters to improve the outcomes of emergency colorectal surgery in Denmark, such as the presence of certified colorectal surgeons during emergency interventions in patients with colorectal cancer. The effects of these measure on the improvement of the quality of care and consequently on postoperative outcomes have not been studied in a homogenous group of patients who underwent emergency surgical interventions related to RSCC.

Received: August 02, 2022. **Revised:** October 12, 2022. **Accepted:** October 20, 2022

The aim of this study was to investigate the trends in morbidity and mortality for patients with RSCC who underwent emergency surgical intervention in Denmark after the introduction of such measures.

The secondary aim was to identify any risk factors associated with short-term postoperative complications.

Materials and methods

Study design

This work was a retrospective population-based study conducted using data from the DCCG database. This prospectively maintained database includes all patients with colorectal cancer who were managed in Danish hospitals. All departments that perform colorectal surgery have a DCCG representative to ensure adherence to DCCG guidelines and proper registration of data. The authors screened all patients with a first-time diagnosis of RSCC between 2001 and 2018 who were managed in Danish hospitals[14]. The completeness of data collection in DCCG is evaluated annually and has increased from 96 per cent to 99 per cent between 2001 and 2018 (https://dccg.dk/). The database has recently been validated, with results showing the high completeness and quality of data[15].

Patients were identified by their Danish Civil Registration Number, a unique 10-digit personal number given to all Danish citizens[16]. The data reported to DCCG from the surgical departments in Denmark include patients' demographics, clinical manifestation, tumour location, Union for International Cancer Control (UICC) tumour stage, diagnostic and therapeutic procedures, and postoperative complications. Data management was conducted according to national ethical guidelines. Danish Data Protection Agency (Datatilsynet) approval was obtained (RN-2018-94).

Patients

The present study included all Danish patients registered in the DCCG with a registered procedure code of RSCC from 1 May 2001 to 30 April 2018. Demographic data, including ASA score, tumour location, and stage were collected.

The resection was classified as laparoscopic when completed as such. Staging was performed according to the UICC TNM system (fifth edition). The Clavien–Demartines–Dindo classification was used to describe the severity of complications. Unplanned intraoperative adverse events (UIAEs) were defined as inadvertent injuries during the operation. Patients were included if they presented with a diagnosis of RSCC (defined as cancer in the caecum, ascending colon, hepatic flexure, and oral part of the transverse colon) at any stage. In addition to RSCC diagnosis, these patients underwent emergency surgical intervention (any intervention within 48 h of admission to the hospital) whether this intervention was performed using open, laparoscopic, single-incision laparoscopic surgery with/without robotic assistance, or endoscopy. Planned palliative resections were excluded but curative intended resections that ended with compromised or palliative resections were included.

Of note, the timing of the operation was registered in the DCCG database (emergency or elective). Patients were excluded if they had synchronous, metachronous, or recurrent RSCC. Data from the included patients were reviewed, including clinical, pathological features, year of intervention, details of surgical procedures, and postoperative recovery in addition to results of follow-up.

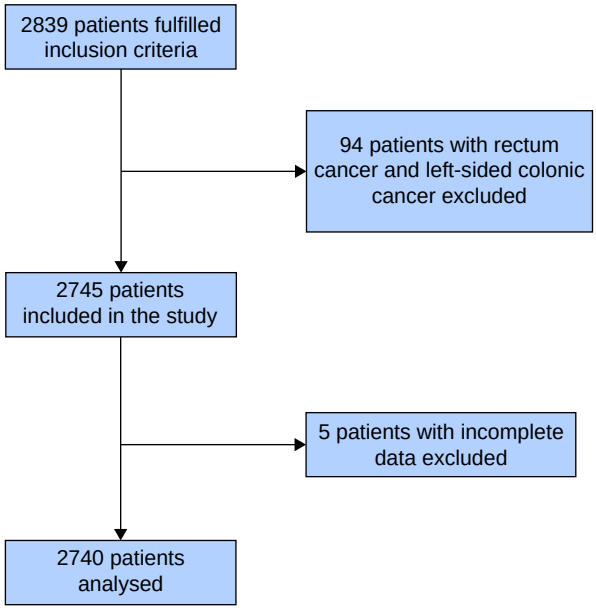

Fig. 1 Patient selection for this study

Data obtained from the Danish Colorectal Cancer Group register. Emergency surgery was defined as surgical intervention within 48 h of admission.

DCCG guidelines for the management of emergency RSCC

The guidelines (in Danish) are published online (https://dccg.dk/wp-content/uploads/2019/11/Akut-kirurgi-colon-ileus_AdmGodk_051119.pdf) and include liberal use of CT with intravenous (i.v.) contrast to assess the colon upon emergency admission and involvement of a certified colorectal surgeon during the surgical treatment of emergency colonic cancer presentations (index quality parameter). The guidelines recommended a de-functioning procedure whenever definitive resection is not appropriate at the time of operation and damage control surgery to be considered as the first choice when the patient's haemodynamic state is compromised.

Definitions of procedure, outcome, and measurements

For the purpose of this research the following definitions were adopted:

- conventional right hemicolectomy (CRHC), defined as a resection of the right colon with a division of the arcade between the two branches of the middle colic artery according to DCCG guidelines.
- extended right hemicolectomy (ERHC), defined as a resection of the right colon with a division of the arcade between the left branch of the middle colic artery and the left colic according to the DCCG guidelines.
- ileo-caecal or ileo-colic resection, defined as a resection of the caecum and oral part of the ascending colon just caudally to the avascular window over the duodenum with a division of the arcade between the ileo-colic artery and right branch of the middle colic artery.
- self-expandable metal stents (SEMSs), defined as endoscopic insertions of metal self-expanding colonic stents to relieve colonic obstruction.

Table 1 Overall postoperative complications

	No complication	Overall complications	Total	*P*	OR, 95% c.i., *P*	Missing values/*n* (%)
Overall complications	1612 (65.6)	846 (34.4)	2458 (100.0)			0 / 2458 (0.0)
Age (years) at time of operation, median (i.q.r.)	72 (16)	76 (15)	73 (16)	0.00	OR 1.012, 95% c.i. 1.004 to 1.02, $P = 0.005$	0 / 2458 (0.0)
Sex (female)	917 (56.9)	466 (55.1)	1383 (56.3)	0.39		0 / 2458 (0.0)
BMI, median (i.q.r.)	24 (5)	24 (6)	24 (5)	0.80		943 / 2458 (38.4)
pT category						
pTx or pT0	20 (1.4)	12 (1.6)	32 (1.4)			
pT1	7 (0.5)	1 (0.1)	8 (0.4)			
pT2	43 (2.9)	26 (3.5)	69 (3.1)			
pT3	740 (50.5)	369 (49.5)	1109 (50.2)			
pT4	655 (44.7)	337 (45.2)	992 (44.9)	0.66		248 / 2458 (10.1)
pN category						
pNx or pN0	629 (39.1)	308 (36.5)	937 (38.2)			
pN1	407 (25.3)	236 (28.0)	643 (26.2)			
pN2	571 (35.5)	299 (35.5)	870 (35.5)	0.29		8 / 2458 (0.3)
ASA score						
ASA1	307 (20.0)	83 (10.3)	390 (16.7)			
ASA2	776 (50.5)	312 (38.9)	1088 (46.5)			
ASA3	402 (26.1)	341 (42.5)	743 (31.7)			
ASA4	51 (3.3)	63 (7.8)	114 (4.9)			
ASA5	2 (0.1)	4 (0.5)	6 (0.3)	0.00	OR 1.61, 95% c.i. 1.422 to 1.830, $P < 0.001$	117 / 2458 (4.8)
Indication for acute operation						
Ileus	1150 (74.5)	614 (76.2)	1764 (75.1)			
Perforation	97 (6.3)	60 (7.4)	157 (6.7)			
Other indications	216 (14.0)	78 (9.7)	294 (12.5)			
Bleeding	80 (5.2)	54 (6.7)	134 (5.7)	0.01		109 / 2458 (4.4)
Charlson's co-morbidity index (CCI)						
CCI 0	950 (58.9)	426 (50.4)	1376 (56.0)			
CCI 1–2	423 (26.2)	272 (32.2)	695 (28.3)			
CCI 3–4	102 (6.3)	81 (9.6)	183 (7.4)			
CCI 5	137 (8.5)	67 (7.9)	204 (8.3)	0.00		0 / 2458 (0.0)
Smoking status						
Non-smoker	376 (37.3)	147 (34.5)	523 (36.4)			
Ex-smoker (more than 8 weeks smoking stop)	342 (33.9)	140 (32.9)	482 (33.6)			
Smoker	291 (28.8)	139 (32.6)	430 (30.0)	0.34		1023 / 2458 (41.6)
Alcohol consumption (units)						
No alcohol consumption	311 (31.2)	124 (30.1)	435 (30.9)			
Alcohol 1–14	563 (56.4)	230 (55.8)	793 (56.2)			
Alcohol 15–21	54 (5.4)	17 (4.1)	71 (5.0)			
Alcohol more than 21	70 (7.0)	41 (10.0)	111 (7.9)	0.23		1048 / 2458 (42.6)
Metastasis	437 (27.9)	230 (28.2)	667 (28.0)	0.89		79 / 2458 (3.2)
Preoperative neoadjuvant chemotherapy	18 (1.1)	11 (1.3)	29 (1.2)	0.69		0 / 2458 (0.0)
Surgeon's specialization						
Colorectal surgeon	387 (90.8)	185 (92.5)	572 (91.4)			
Trainee or general surgeon	39 (9.2)	15 (7.5)	54 (8.6)	0.49		1832 / 2458 (74.5)
Type of surgical resection						
Ileo-caecal resection	28 (1.7)	18 (2.1)	46 (1.9)			
Right hemi-colectomy	1470 (91.2)	770 (91.0)	2240 (91.1)			
Extended right hemi-colectomy	75 (4.7)	36 (4.3)	111 (4.5)			
Resection of transverse colon	39 (2.4)	22 (2.6)	61 (2.5)	0.87		0 / 2458 (0.0)
Tumour location						
Caecum	799 (49.6)	411 (48.6)	1210 (49.2)			
Ascending colon	350 (21.7)	141 (16.7)	491 (20.0)			
Hepatic flexure	219 (13.6)	124 (14.7)	343 (14.0)			
Transverse colon	244 (15.1)	170 (20.1)	414 (16.8)	0.00	OR 1.324, 95% c.i. 1.042 to 1.681, $P = 0.022$	0 / 2458 (0.0)
Access to abdominal cavity						
Laparoscopic	85 (5.3)	17 (2.0)	102 (4.1)			
Converted	75 (4.7)	35 (4.1)	110 (4.5)			
Laparotomy	1452 (90.1)	794 (93.9)	2246 (91.4)	0.00		0 / 2458 (0.0)
Supplementary resection	293 (18.2)	161 (19.0)	454 (18.5)	0.61		1 / 2458 (0.0)

Values are *n* (%) unless otherwise indicated. This table describes the results of multivariate analysis of variables associated with overall postoperative complications (Clavien–Dindo grades II–IV). Data describe demographics and perioperative characteristics of patients who underwent emergency colectomy to treat right-sided colonic cancer. Data were obtained from the Danish Colorectal Cancer Group register. Emergency surgery is defined as surgical intervention within 48 h of admission. i.q.r., interquartile range.

- stomas, defined as the construction of a functioning stoma (ileostomy or colostomy) without anastomosis or oncological resection at the time of index surgery.
- DCCG registration form defines surgical complications as anastomotic leakage, surgical site infection, bleeding, bowel obstruction, and stoma-related complications,

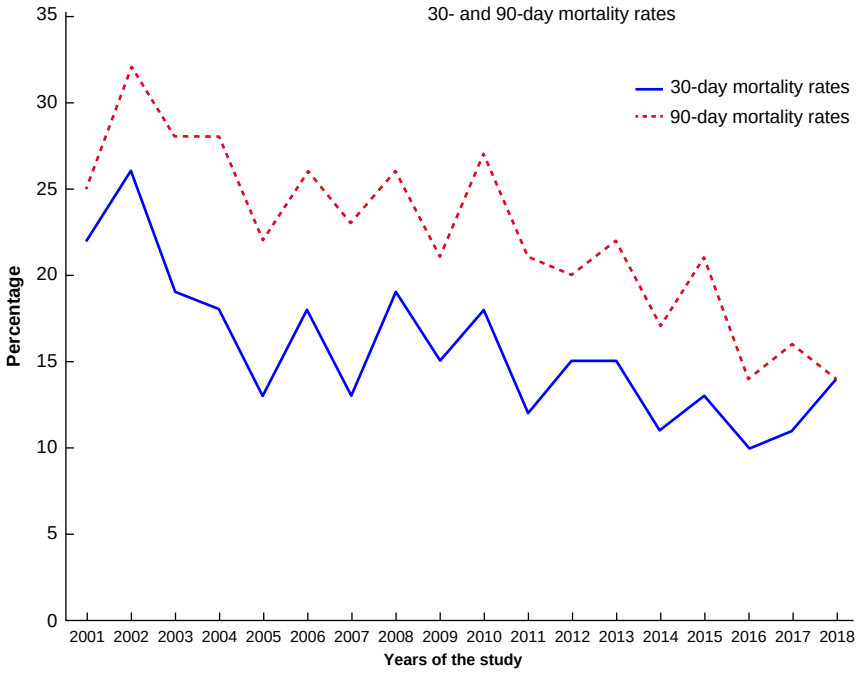

Fig. 2 30-and 90 days postoperative mortality rates in patients with right-sided colonic cancer who underwent emergency surgical interventions
The study is based on nationwide prospectively collected data set.

whereas medical complications include stroke, myocardial infarction, pneumonia, heart failure, thrombo-embolic events, lung failure, renal failure, and sepsis.

- one unit of alcohol is defined in Denmark as equivalent to 15 ml or 12 g of alcoholic drink.

Outcome of interest

The primary objective was to investigate the trends in morbidity and mortality of patients with RSCC who underwent emergency surgical intervention in Denmark.

The secondary objective was to identify modifiable risk factors associated with short-term postoperative complications.

As secondary analyses, patients who had colonic resections were compared with those who had a de-functioning procedure. Also, another comparison was performed using a cohort of patients who had emergency RSCC resection (within 48 h of admission) obtained from the snapshot audit conducted in 2015 by the European Society of Colo-Proctology (ESCP), aiming to investigate outcomes in two comparable homogenous cohorts. Danish patients were excluded from this cohort to prevent duplicate presentation of patients.

Statistical analyses

Descriptive summaries are presented with median and interquartile range (i.q.r.) or percentages, and categorical variables are reported as frequencies with percentages of the total number of observations, as appropriate. Multivariate estimates were adjusted for age, sex, smoking status, alcohol consumption, ASA score, tumour localization, type of access to the abdominal cavity, surgeon's grade of specialization, and metastatic disease at baseline and calendar year. To address the missing values, multiple imputation using chained equations (MICE) was used. Multiple imputation aims to allow for the uncertainty about the missing data by creating several different plausible imputed data sets and appropriately combining results obtained from each of them.

The details of the overall complication rates of the cohort of patients who underwent surgery (de-functioning stoma and stent excluded) and the risk factors associated with these complications were analysed, and overall postoperative complications were noted. Chi-squared tests were used, and logistic regressions were fitted to estimate ORs with 95 per cent confidence intervals for demographics and perioperative characteristics as a function of overall postoperative complications. Patients who underwent a definitive procedure (surgery), and those who underwent a de-functional procedure (SEMS insertion or stoma construction, without oncological resection), were compared to explore the characteristics of patients who had these interventions. The analysis was performed using chi-squared tests and logistic regression, as described above. Subsequently, the outcomes in the cohort of patients who were likely to be fit (patients with no co-morbidities and high performance), were compared with those of patients who had a compromised status at the time of operation/intervention to explore any modifiable risk factors in the fit-to-fight group. Identifying such modifiable risk factors may help to stratify and to optimize these patients before surgery. Compromised status was defined as patients with metastatic disease at the time of operation, who were operated on with curative intent but intraoperatively were found to have unresectable disease; therefore, surgery was changed to palliative or compromised resections (compromised resection is a resection that does not follow the DCCG-recommended total mesocolic excision) in addition to patients who were treated with de-functioning procedures, such as the construction of a stoma or insertion of SEMS. Patients with an ASA score of 4 or 5 were also considered to have had a compromised resection.

The effect of time on the following variables after adjusting for demographics was compared in the entire cohort: overall postoperative complications, postoperative surgical

Table 2 Medical postoperative complications

	No postoperative medical complications	Postoperative medical complications	Total	P	OR, 95% c.i., P	Missing values/n (%)
Postoperative medical complications	1936 (78.8)	522 (21.2)	2458 (100.0)			0 / 2458 (0.0)
Age (years) at time of operation, median (i.q.r.)	72 (16)	79 (12)	73 (16)	<0.01	OR 1.034, 95% c.i. 1.023 to 1.045, $P < 0.001$	0 / 2458 (0.0)
Sex (female)	1094 (56.5)	289 (55.4)	1383 (56.3)	0.64	OR 0.797, 95% c.i. 0.647 to 0.982, $P = 0.033$	0 / 2458 (0.0)
BMI, median (i.q.r.)	24 (5)	24 (5)	24 (5)	0.39		943 / 2458 (38.4)
pT category						
pTx or pT0	25 (1.4)	7 (1.5)	32 (1.4)			
pT1	7 (0.4)	1 (0.2)	8 (0.4)			
pT2	54 (3.1)	15 (3.3)	69 (3.1)			
pT3	883 (50.5)	226 (49.1)	1109 (50.2)			
pT4	781 (44.6)	211 (45.9)	992 (44.9)	0.96		248 / 2458 (10.1)
pN category						
pNx or pN0	741 (38.4)	196 (37.7)	937 (38.2)			
pN1	496 (25.7)	147 (28.3)	643 (26.2)			
pN2	693 (35.9)	177 (34.0)	870 (35.5)	0.48		8 / 2458 (0.3)
ASA score						
ASA1	360 (19.5)	30 (6.0)	390 (16.7)			
ASA2	915 (49.6)	173 (34.9)	1088 (46.5)			
ASA3	510 (27.6)	233 (47.0)	743 (31.7)			
ASA4	58 (3.1)	56 (11.3)	114 (4.9)			
ASA5	2 (0.1)	4 (0.8)	6 (0.3)	<0.01	OR 1.863, 95% c.i. 1.602 to 2.167, $P < 0.001$	117 / 2458 (4.8)
Indication for acute operation						
Ileus	1383 (74.8)	381 (76.0)	1764 (75.1)			
Perforation	113 (6.1)	44 (8.8)	157 (6.7)			
Other indications	255 (13.8)	39 (7.8)	294 (12.5)			
Bleeding	97 (5.2)	37 (7.4)	134 (5.7)	<0.01		109 / 2458 (4.4)
Charlson's co-morbidity index (CCI)						
CCI 0	1137 (58.7)	239 (45.8)	1376 (56.0)			
CCI 1–2	518 (26.8)	177 (33.9)	695 (28.3)			
CCI 3–4	116 (6.0)	67 (12.8)	183 (7.4)			
CCI 5	165 (8.5)	39 (7.5)	204 (8.3)	<0.01	OR 1.533, 95% c.i. 1.072 to 2.193, $P = 0.019$	0 / 2458 (0.0)
Smoking status						
Non-smoker	436 (36.7)	87 (35.4)	523 (36.4)			
Ex-smoker (more than 8 weeks smoking stop)	401 (33.7)	81 (32.9)	482 (33.6)			
Smoker	352 (29.6)	78 (31.7)	430 (30.0)	0.80		1023 / 2458 (41.6)
Alcohol consumption (units)						
No alcohol consumption	348 (29.7)	87 (36.4)	435 (30.9)			
Alcohol 1–14	671 (57.3)	122 (51.0)	793 (56.2)			
Alcohol 15–21	61 (5.2)	10 (4.2)	71 (5.0)			
Alcohol more than 21	91 (7.8)	20 (8.4)	111 (7.9)	0.19		1048 / 2458 (42.6)
Metastasis	527 (28.0)	140 (28.2)	667 (28.0)	0.92		79 / 2458 (3.2)
Preoperative neoadjuvant chemotherapy	22 (1.1)	7 (1.3)	29 (1.2)	0.70		0 / 2458 (0.0)
Surgeon's specialization						
Colorectal surgeon	456 (90.5)	116 (95.1)	572 (91.4)			
Trainee or general surgeon	48 (9.5)	6 (4.9)	54 (8.6)	0.10		1832 / 2458 (74.5)
Type of surgical resection						
Ileo-caecal resection	33 (1.7)	13 (2.5)	46 (1.9)			
Right hemi-colectomy	1762 (91.0)	478 (91.6)	2240 (91.1)			
Extended right hemi-colectomy	91 (4.7)	20 (3.8)	111 (4.5)			
Resection of transverse colon	50 (2.6)	11 (2.1)	61 (2.5)	0.49		0 / 2458 (0.0)
Tumour location						
Caecum	953 (49.2)	257 (49.2)	1210 (49.2)			
Ascending colon	399 (20.6)	92 (17.6)	491 (20.0)			
Hepatic flexure	271 (14.0)	72 (13.8)	343 (14.0)			
Transverse colon	313 (16.2)	101 (19.3)	414 (16.8)	0.23		0 / 2458 (0.0)
Access to abdominal cavity						
Laparoscopic	94 (4.9)	8 (1.5)	102 (4.1)			
Converted	88 (4.5)	22 (4.2)	110 (4.5)			
Laparotomy	1754 (90.6)	492 (94.3)	2246 (91.4)	<0.01	OR 2.562, 95% c.i. 1.202 to 5.463, $P = 0.015$	0 / 2458 (0.0)

(continued)

Table 2 (continued)

	No postoperative medical complications	Postoperative medical complications	Total	P	OR, 95% c.i., P	Missing values/*n* (%)
Supplementary resection, *n* (%)	362 (18.7)	92 (17.6)	454 (18.5)	0.57		1 / 2458 (0.0)
Resected lymph nodes, median (i.q.r.)	17 (13)	14 (13)	16 (14)	<0.01		57 / 2458 (2.3)
Resected lymph nodes with metastasis, median (i.q.r.)	2 (6)	2 (6)	2 (6)	0.86		69 / 2458 (2.8)

Values are *n* (%) unless otherwise indicated. This table describes the results of the multivariate analysis of variables associated with postoperative medical complications in patients who underwent emergency colectomy to treat right-sided colonic cancer. Medical postoperative complications were defined as sepsis, cardiopulmonary, and thrombo-embolic complications. Data were obtained from the Danish Colorectal Cancer Group register. Emergency surgery is defined as surgical intervention within 48 h of admission. i.q.r., interquartile range.

complications, postoperative medical complications, 30-day mortality, 90-day mortality, SEMS, de-functioning stoma, laparoscopy, and conversion from laparoscopy to open access.

All statistical analyses were performed using StataMP 17 (StataCorp, College Station, TX, USA).

Results

Out of 2839 patients treated during the study interval, a total of 2740 patients fulfilled the inclusion criteria, of whom 2464 underwent a segmental colonic resection (89.9 per cent) (*Fig. 1*). A stoma (with/without resection) was constructed in 276 patients (10 per cent), whereas SEMS was used in only eight patients. The mean age was 72 years (median 74 with i.q.r. 65–81 years). More than half of the cohort was female (55.8 per cent). Most tumours were in the caecum, followed by the ascending colon, and hepatic flexure, and the fewest were in the transverse colon (*Table 1*).

The 30-day and 90-day postoperative mortality rates were significantly reduced over the time of the study (OR 0.943, 95 per cent c.i. 0.922 to 0.965, $P < 0.001$ and OR 0.953, 95 per cent c.i. 0.934 to 0.972, $P < 0.001$ respectively). The changes of mortality rates over time are shown in *Fig. 2*.

Over the years covered by the study, the rates of stoma construction (OR 1.270, 95 per cent c.i. 1.23 to 1.315, $P < 0.001$), laparoscopic interventions (OR 1.235, 95 per cent c.i. 1.174 to 1.299, $P < 0.001$), and conversion during laparoscopy (OR 1.284, 95 per cent c.i. 1.219 to 1.351, $P < 0.001$) significantly increased (*Table S1*).

Postoperative complication rates

Multivariate analyses showed that the year of intervention did not affect rates of postoperative overall, medical, and surgical complications (*Table S1*). Age, ASA score, and tumour location in the transverse colon were the most significant risk factors associated with postoperative complications in the group of patients who underwent colectomy (*Table 1*).

Two of these factors also influenced the severity of complications: patients of older age (OR 1.032, 95 per cent c.i. 1.009 to 1.055, $P = 0.005$) and patients with high ASA scores (OR 1.61, 95 per cent c.i. 1.422 to 1.830, $P < 0.001$) had higher rates of Clavien–Demartines–Dindo grade 3b postoperative complications and above (*Table S2*). These findings were shown in the cohort of patients who had of surgical complications (*Table S3*).

Smokers had a two times higher risk of intra-abdominal septic complications (IASCs) than non-smokers (OR 1.930, 95 per cent c.i. 1.047 to 3.558, $P = 0.035$). Tumour location in the transverse colon doubled the risk of IASCs (OR 2.261, 95 per cent c.i. 1.425 to 3.589, $P = 0.001$) (*Tables S4–S8*). IASCs were defined as anastomotic leak, intra-abdominal abscess, or enteric fistula.

In addition to age and ASA score, patients with high alcohol consumption (more than 21 units per week) had a higher risk of postoperative surgical complications (OR 2.516, 95 per cent c.i. 1.520 to 4.165, $P < 0.001$), such as intra-abdominal septic complications (OR 2.516, 95 per cent c.i. 1.520 to 4.165, $P < 0.001$), and wound dehiscence (OR 2.935, 95 per cent c.i. 1.317 to 6.543, $P = 0.009$). Conversely, the effect of high alcohol consumption on postoperative medical complications, such as sepsis and cardiopulmonary and thrombo-embolic complications, was not significant, as shown in *Tables S9–S11*.

Postoperative medical complications were mainly associated with older age (OR 1.034, 95 per cent c.i. 1.023 to 1.045, $P < 0.001$), higher ASA scores (OR 1.61, 95 per cent c.i. 1.422 to 1.830, $P < 0.001$), higher Charlson co-morbidity index (CCI) (OR 1.533, 95 per cent c.i. 1.072 to 2.193, $P = 0.019$), and laparotomy (OR 2.562, 95 per cent c.i. 1.202 to 5.463, $P = 0.015$). Women had a lower risk of postoperative medical complications than men (OR 0.797, 95 per cent c.i. 0.647 to 0.982, $P = 0.033$) (*Table 2*).

Postoperative mortality

The 30-day postoperative mortality (OR 0.618, 95 per cent c.i. 0.461 to 0.828, $P = 0.001$) was lower in women than in men, as shown in *Table 3*. Tumour location in the transverse colon (OR 1.866, 95 per cent c.i. 1.283 to 2.712, $P = 0.001$), tumour perforation (OR 2.275, 95 per cent c.i. 1.429 to 3.619, $P = 0.001$) and metastasis (OR 1.658, 95 per cent c.i. 1.207 to 2.274, $P = 0.002$) increased the risk of 30-day postoperative mortality. Age and ASA score remained significant factors in 30-day postoperative mortality after adjusting for confounding factors, as shown in *Table 3*. This pattern was also noticed in 90-day postoperative mortality, for which age, ASA score, CCI ,and tumour perforation were the most significant risk factors in addition to metastasis and BMI (*Table S12*).

Resections *versus* de-functioning procedures

The characteristics of patients who had definitive surgical procedures (resections), were then compared with those who received only de-functioning procedures (stoma construction or SEMS without oncological resection). Patients who underwent de-functioning procedures were mostly men (OR 1.485, 95 per cent c.i. 1.117 to 1.974, $P = 0.007$), had higher ASA scores (OR 0.7349, 95 per cent c.i. 0.608 to 0.889, $P = 0.001$), a higher CCI (OR 0.659, 95 per cent c.i. 0.477 to 0.910, $P = 0.011$), received preoperative chemotherapy (OR 0.137, 95 per cent c.i. 0.0698 to 0.268, $P < 0.001$), and/or had preoperative tumour perforation (OR 0.132, 95 per cent c.i. 0.095 to 0.182 $P < 0.001$) (*Table 4*). However, the de-functioning procedure did not protect these patients from the high risk of postoperative complications or postoperative 90-day mortality, as shown in *Table 5*.

Table 3 Thirty-day postoperative mortality

	No postoperative 30-day mortality	Postoperative 30-day mortality	Total	*P*	OR, 95% c.i., *P*	Missing values/*n* (%)
Postoperative 30-day mortality	2097 (85.3)	361 (14.7)	2458 (100.0)			0 / 2458 (0.0)
Age (years) at time of operation, median (i.q.r.)	72 (16)	81 (12)	73 (16)	0.00	OR 1.062, 95% c.i. 1.046 to 1.078, $P < 0.001$	0 / 2458 (0.0)
Sex (female)	1186 (56.6)	197 (54.6)	1383 (56.3)	0.48	OR 0.618, 95% c.i. 0.461 to 0.828, $P = 0.001$	0 / 2458 (0.0)
BMI, median (i.q.r.)	24 (5)	23 (5)	24 (5)	0.01		943 / 2458 (38.4)
pT category						
pTx or pT0	21 (1.1)	11 (3.6)	32 (1.4)			
pT1	7 (0.4)	1 (0.3)	8 (0.4)			
pT2	60 (3.1)	9 (3.0)	69 (3.1)			
pT3	978 (51.3)	131 (43.2)	1109 (50.2)			
pT4	841 (44.1)	151 (49.8)	992 (44.9)	0.00		248 / 2458 (10.1)
pN category						
pNx or pN0	809 (38.7)	128 (35.5)	937 (38.2)			
pN1	541 (25.9)	102 (28.3)	643 (26.2)			
pN2	739 (35.4)	131 (36.3)	870 (35.5)	0.45		8 / 2458 (0.3)
ASA score						
ASA1	376 (18.7)	14 (4.2)	390 (16.7)			
ASA2	999 (49.7)	89 (26.9)	1088 (46.5)			
ASA3	575 (28.6)	168 (50.8)	743 (31.7)			
ASA4	58 (2.9)	56 (16.9)	114 (4.9)			
ASA5	2 (0.1)	4 (1.2)	6 (0.3)	0.00	OR 2.219, 95% c.i. 1.821 to 2.704, $P = 0.000$	117 / 2458 (4.8)
Indication for acute operation						
Ileus	1505 (75.0)	259 (75.5)	1764 (75.1)			
Perforation	118 (5.9)	39 (11.4)	157 (6.7)		OR 2.275, 95% c.i. 1.429 to 3.619, $P = 0.001$	
Other indications	279 (13.9)	15 (4.4)	294 (12.5)			
Bleeding	104 (5.2)	30 (8.7)	134 (5.7)	0.00		109 / 2458 (4.4)
Charlson's comorbidity index (CCI)						
CCI 0	1232 (58.8)	144 (39.9)	1376 (56.0)			
CCI 1–2	558 (26.6)	137 (38.0)	695 (28.3)			
CCI 3–4	136 (6.5)	47 (13.0)	183 (7.4)			
CCI 5	171 (8.2)	33 (9.1)	204 (8.3)	0.00		0 / 2458 (0.0)
Smoking status						
Non-smoker	480 (36.6)	43 (34.4)	523 (36.4)			
Ex-smoker (more than 8 weeks smoking stop)	441 (33.7)	41 (32.8)	482 (33.6)			
Smoker	389 (29.7)	41 (32.8)	430 (30.0)	0.76		1023 / 2458 (41.6)
Alcohol consumption (units)						
No alcohol consumption	383 (29.6)	52 (44.1)	435 (30.9)			
Alcohol 1–14	734 (56.8)	59 (50.0)	793 (56.2)			
Alcohol 15–21	70 (5.4)	1 (0.8)	71 (5.0)			
Alcohol more than 21	105 (8.1)	6 (5.1)	111 (7.9)	0.00		1048 / 2458 (42.6)
Metastasis	546 (26.7)	121 (36.3)	667 (28.0)	0.00	OR 1.658, 95% c.i. 1.207 to 2.274, $P = 0.002$	79 / 2458 (3.2)
Preoperative neoadjuvant chemotherapy	26 (1.2)	3 (0.8)	29 (1.2)	0.51		0 / 2458 (0.0)
Surgeon's specialization						
Colorectal surgeon	481 (90.4)	91 (96.8)	572 (91.4)			
Trainee or general surgeon	51 (9.6)	3 (3.2)	54 (8.6)	0.04		1832 / 2458 (74.5)
Type of surgical resection						
Ileo-caecal resection	37 (1.8)	9 (2.5)	46 (1.9)			
Right hemi-colectomy	1905 (90.8)	335 (92.8)	2240 (91.1)			
Extended right hemi-colectomy	108 (5.2)	3 (0.8)	111 (4.5)			
Resection of transverse colon	47 (2.2)	14 (3.9)	61 (2.5)	0.00		0 / 2458 (0.0)
Tumour location						
Caecum	1035 (49.4)	175 (48.5)	1210 (49.2)			
Ascending colon	434 (20.7)	57 (15.8)	491 (20.0)			
Hepatic flexure	297 (14.2)	46 (12.7)	343 (14.0)			
Transverse colon	331 (15.8)	83 (23.0)	414 (16.8)	0.00	OR 1.866, 95% c.i. 1.283 to 2.712, $P = 0.001$	0 / 2458 (0.0)
Access to abdominal cavity						
Laparoscopic	100 (4.8)	2 (0.6)	102 (4.1)			
Converted	101 (4.8)	9 (2.5)	110 (4.5)			
Laparotomy	1896 (90.4)	350 (97.0)	2246 (91.4)	0.00		0 / 2458 (0.0)
Supplementary resection	379 (18.1)	75 (20.8)	454 (18.5)	0.22		1 / 2458 (0.0)

Values are *n* (%) unless otherwise indicated. This table describes the results of the multivariate analysis of variables associated with 30-day postoperative mortality. Data describe demographics and perioperative characteristics of patients who underwent emergency colectomy to treat right-sided colonic cancer. Data were obtained from the Danish Colorectal Cancer Group register. Emergency surgery is defined as surgical intervention within 48 h of admission. i.q.r., interquartile range.

Table 4 Demographics of patients who had definitive versus those who had de-functioning procedures

	De-functioning procedures	Definitive surgery	Total	P	OR, 95% c.i., P	Missing values/n (%)
Surgical approach	276 (10.1)	2464 (89.9)	2740 (100.0)			0 / 2740 (0.0)
Age (years) at time of operation, median (i.q.r.)	77 (15)	73 (16)	74 (16)	0.01		0 / 2740 (0.0)
Sex (female)	143 (51.8)	1387 (56.3)	1530 (55.8)	0.16	OR 1.485, 95% c.i. 1.117 to 1.974, P = 0.007	0 / 2740 (0.0)
BMI, median (i.q.r.)	24 (7)	24 (5)	24 (5)	0.97		985 / 2740 (35.9)
pT category						
pTx or pT0	3 (1.1)	32 (1.4)	35 (1.4)			
pT1	3 (1.1)	8 (0.4)	11 (0.4)			
pT2	2 (0.7)	69 (3.1)	71 (2.9)			
pT3	117 (43.3)	1112 (50.2)	1229 (49.4)			
pT4	145 (53.7)	995 (44.9)	1140 (45.9)	0.01		254 / 2740 (9.3)
pN category						
pNx or pN0	118 (43.2)	940 (38.3)	1058 (38.8)			
pN1	62 (22.7)	645 (26.3)	707 (25.9)			
pN2	93 (34.1)	871 (35.5)	964 (35.3)	0.24		11 / 2740 (0.4)
ASA score						
ASA1	21 (7.7)	391 (16.7)	412 (15.7)			
ASA2	103 (38.0)	1090 (46.4)	1193 (45.6)			
ASA3	120 (44.3)	746 (31.8)	866 (33.1)			
ASA4	25 (9.2)	114 (4.9)	139 (5.3)			
ASA5	2 (0.7)	6 (0.3)	8 (0.3)	0.00	OR 0.7349, 95% c.i. 0.608 to 0.889, P = 0.001	122 / 2740 (4.4)
Indication for acute operation						
Ileus	146 (52.9)	1770 (75.2)	1916 (72.8)			
Perforation	96 (34.8)	157 (6.7)	253 (9.6)		OR 0.132, 95% c.i. 0.095 to 0.182, P = 0.000	
Other indications	31 (11.2)	294 (12.5)	325 (12.4)			
Bleeding	3 (1.1)	134 (5.7)	137 (5.2)	0.00	OR 4.408695, 95% c.i. 1.373 to 14.161, P = 0.013	109 / 2740 (4.0)
Charlson's comorbidity index (CCI)						
CCI 0	112 (40.6)	1379 (56.0)	1491 (54.4)			
CCI 1–2	93 (33.7)	696 (28.2)	789 (28.8)		OR 0.659, 95% c.i. 0.477 to 0.910, P = 0.011	
CCI 3–4	36 (13.0)	185 (7.5)	221 (8.1)		OR 0.475, 95% c.i. 0.301 to 0.749, P = 0.001	
CCI 5	35 (12.7)	204 (8.3)	239 (8.7)	0.00	OR 0.477, 95% c.i. 0.304 to 0.749, P = 0.001	0 / 2740 (0.0)
Smoking status						
Non-smoker	73 (32.9)	524 (36.4)	597 (35.9)			
Ex-smoker (more than 8 weeks smoking stop)	71 (32.0)	485 (33.7)	556 (33.5)			
Smoker	78 (35.1)	431 (29.9)	509 (30.6)	0.28		1078 / 2740 (39.3)
Alcohol consumption (units)						
No alcohol consumption	88 (39.3)	436 (30.8)	524 (32.0)			
Alcohol 1–14	107 (47.8)	797 (56.3)	904 (55.2)			
Alcohol 15–21	15 (6.7)	71 (5.0)	86 (5.2)			
Alcohol more than 21	14 (6.3)	111 (7.8)	125 (7.6)	0.04		1101 / 2740 (40.2)
Metastasis	84 (33.5)	668 (28.0)	752 (28.5)	0.07		104 / 2740 (3.8)
Preoperative neoadjuvant chemotherapy	19 (6.9)	30 (1.2)	49 (1.8)	0.00	OR 0.137, 95% c.i. 0.0698 to 0.268, P = 0.000	0 / 2740 (0.0)

Values are *n* (%) unless otherwise indicated. This table describes the results of the multivariate analysis demographics and perioperative characteristics of patients who underwent emergency definitive surgery to treat right-sided colonic cancer (segmental colectomy) compared with patients who had a de-functioning procedure (colonic SEMS or stoma). Data were obtained from the Danish Colorectal Cancer Group register. Emergency surgery is defined as surgical intervention within 48 h of admission. i.q.r., interquartile range.

Bleeding, open access surgery, tumour located at transverse colon, and ASA score were significantly correlated with postoperative severe complications in patients who were considered more fit for surgery at the time of presentation (*Table S13*).

Comparison with ESCP 2015 audit

The ESCP snapshot audit in 2015, showed that IASCs occurred in 29 of 212 of cases (13.7 per cent) and wound infection in 43 of 253 cases (17 per cent), whereas UIAEs were encountered in 26

Table 5 Postoperative outcomes in patients who had definitive *versus* those who had de-functioning procedures

	De-functioning procedures	Definitive surgery	Total	*P*	OR, 95% c.i., *P*	Missing values/*n* (%)
Surgical approach	276 (10.1)	2464 (89.9)	2740 (100.0)			0 / 2740 (0.0)
Overall complications	135 (48.9)	850 (34.5)	985 (35.9)	0.00		0 / 2740 (0.0)
Postoperative complications (surgical)	69 (25.0)	462 (18.8)	531 (19.4)	0.01		0 / 2740 (0.0)
IASCs	10 (3.6)	152 (6.2)	162 (5.9)	0.09		0 / 2740 (0.0)
Postoperative wound dehiscence	19 (6.9)	134 (5.4)	153 (5.6)	0.32		0 / 2740 (0.0)
Postoperative ileus,	5 (1.8)	51 (2.1)	56 (2.0)	0.77		0 / 2740 (0.0)
Postoperative bleeding	4 (1.4)	27 (1.1)	31 (1.1)	0.60		0 / 2740 (0.0)
Postoperative sepsis,	53 (19.2)	152 (6.2)	205 (7.5)	0.00	OR 0.551, 95% c.i. 0.338 to 0.897, *P* = 0.017	0 / 2740 (0.0)
Postoperative medical complications	105 (38.0)	525 (21.3)	630 (23.0)	0.00	OR 0.356, 95% c.i. 0.161 to 0.788, *P* = 0.011	0 / 2740 (0.0)
Cardiopulmonary complications	67 (24.3)	405 (16.4)	472 (17.2)	0.00		0 / 2740 (0.0)
Thrombo-embolic complications	11 (4.0)	38 (1.5)	49 (1.8)	0.00		0 / 2740 (0.0)
Postoperative 30-day mortality	64 (23.2)	363 (14.7)	427 (15.6)	0.00	OR 1.753, 95% c.i. 1.082 to 2.841, *P* = 0.023	0 / 2740 (0.0)
Postoperative 90-day mortality	102 (37.0)	527 (21.4)	629 (23.0)	0.00	OR 0.432, 95% c.i. 0.289 to 0.646, *P* < 0.001	0 / 2740 (0.0)
UIAEs	12 (4.3)	83 (3.4)	95 (3.5)	0.40		0 / 2740 (0.0)
Severe complications	38 (13.8)	94 (3.8)	132 (4.8)	0.00	OR 0.329, 95% c.i. 0.208 to 0.519, *P* < 0.001	0 / 2740 (0.0)

Values are *n* (%) unless otherwise indicated. This table describes the results of the multivariate analysis of postoperative outcomes in patients who underwent emergency definitive surgery to treat right-sided colonic cancer (segmental colectomy) compared with patients who had a de-functioning procedure (colon SEMS or stoma). Data were obtained from the Danish Colorectal Cancer Group register. Emergency surgery is defined as surgical intervention within 48 h of admission. IASC, intra-abdominal septic complications; UIAEs, unplanned intraoperative adverse events.

Table 6 Cohort from European Society of Colo-Proctology snapshot audit

	No complication	Overall complications	Total	*P*	OR, 95% c.i., *P*	Missing values/*n* (%)
Overall complications	1612 (65.6)	846 (34.4)	2538 (100.0)			0 / 253 (0.0)
Age (years) at time of operation, median (i.q.r.)	71 (63–79.6)	76 (66–85)	73.5 (64–82)	0.02		0 / 253 (0.0)
Sex (female)	64 (57.1)	55 (39)	119 (47) (56.3)	0.04	OR 0.179, 95% c.i. 0.173 to 0.298, *P* = 0.003	0 / 253 (0.0)
BMI, median (i.q.r.)	25 (22.6–28)	24 (21.9–29)	24 (22–28)	0.535		18 / 253 (7.1)
ASA score						
ASA1	13 (11.6)	6 (4.3)	19 (7.5)			
ASA2	47 (42.0)	48 (34.0)	95 (37.5)			
ASA3	45 (40.2)	69 (48.9)	114 (45.1)			
ASA4	7 (6.3)	15 (10.6)	22 (8.7)			
ASA5	0 (0)	3 (2)	3 (1.2)	0.035	OR 0.9, 95% c.i. 0.008 to 0.173, *P* = 0.032	253 / 253 (0.0)
Smoking status						
Non-smoker	70 (70)	77 (61.5)	147 (65)			
Ex-smoker (more than 8 weeks smoking stop)	14 (14)	21 (16.7)	35 (15.5)			
Smoker	16 (16)	28 (22.2)	44 (19.5)	0.36		226 / 253 (10.7)
Preoperative neoadjuvant chemotherapy	2 (1.9)	0 (0)	2 (0.8)	0.112		243 / 253 (3.9)
Surgeon's specialization						
Colorectal surgeon	50 (44.6)	71 (50.4)	121 (47.8)			
Trainee or general surgeon	62 (55.4)	70 (49.6)	132 (52.2)	0.366		235 / 253 (0.0)
Type of surgical resection						
Ileo-caecal resection	14 (5.5)	18 (7.1)	32 (12.6)			
Right hemi-colectomy	82 (32.4)	105 (41.5)	187 (73.9)			
Extended right hemi-colectomy	8 (3.2)	12 (4.7)	20 (7.9)			
Resection of transverse colon	6 (2.4)	4 (1.6)	10 (3.9)	0.87		0 / 253 (0.0)
Other resections	2 (0.8)	2 (0.8)	4 (1.6)			
Access to abdominal cavity						
Laparoscopic	4 (3.6)	6 (4.3)	10 (4)			
Converted	8 (7.1)	5 (3.5)	13 (5.1)			
Laparotomy	100 (89.3)	130 (92.2)	230 (90.9)	0.313		0 / 253 (0.0)

Values are *n* (%) unless otherwise indicated. This table describes the results of the multivariate analysis demographics and perioperative characteristics of patients who underwent emergency colectomy to treat right-sided colonic cancer. The table shows the results from an international cohort obtained for the ESCP snapshot audit in 2015. Emergency surgery is defined as surgical intervention within 48 h of admission. ESCP, European Society of Colo-Proctology; i.q.r., interquartile range.

of 235 cases (10.3 per cent). The results showed lower occurrence of IASCs in the Danish cohort, fewer UIAEs and less ileo-caecal and less extended right colon resection compared with the international cohort (*Table 6*).

Discussion

This nationwide, population-based study showed a decrease in 30- and 90-day postoperative mortality in patients with RSCC who underwent emergency surgical intervention in Denmark throughout the study years.

The DCCG guidelines might have played a role in this improvement by upgrading the quality of care.

Compared with the ESCP snapshot audit in 2015, intra-abdominal septic complications occurred in 29 of 212 (13.7 per cent) patients, wound infections were observed in 43 of 253 (17 per cent) patients, and unplanned intraoperative adverse events were documented in 26 of 235 (10.3 per cent) patients. The results showed that the incidences of IASCs, UIAEs, ileo-caecal resection, and extended right colon resection were lower in the Danish cohort than in the international cohort. Colorectal surgeons performed more than 90 per cent of the interventions in Denmark compared with approximately 50 per cent of the interventions in the ESCP international cohort. This difference might explain the lower rates of UIAEs in the Danish cohort (95 of 2740 (3.5 per cent) *versus* 26 of 235 (10.3 per cent)); however, the surgeons' grade of specialization did not influence the choice of access to the abdominal cavity, as laparotomy was the dominant procedure in both cohorts.

A previous study[6] reviewed nine studies that included 600 patients treated with curative intent for right-sided obstructing colonic cancer with emergency resection or staged resection. The mean overall postoperative complication rate was 42 per cent after emergency resection, whereas the overall complication rate in our cohort was only 35 per cent; however, the present cohort experienced higher mortality rates, which might be due to the inclusion of patients who had perforation and bleeding as well as obstruction.

SEMS placement as a bridge to surgery is considered an advanced procedure that requires endoscopists with expertise for the placement of right-sided stents. This feature may explain the limited use of SEMSs in our cohort compared to that of the previous review, in which 77 patients (13 per cent) had SEMSs as a bridge to surgery. Alternatively, right-sided stenting is underreported because failure to insert SEMS usually leads to resection or stoma construction, and these two procedures are coded differently in the DCCG database.

Notably, avoiding definitive surgery (oncological resection), in patients who are deemed to have comprised status did not reduce complications or mortality rates. Therefore, avoiding surgery is insufficient, and these patients may benefit from early, protocolized preoperative optimization. In this regard, our study may serve as an important baseline to evaluate the impact of preoperative optimization in patients with RSCC who undergo emergency surgical interventions. Optimization includes individually tailored fluid correction, the control of sepsis, damage control surgery, or decompression using colonic SEMS or stoma[17].

The study confirmed the conclusion of two recent population-based studies[18,19], that age is the most important factor that influences postoperative outcome. In addition to age, a high ASA score and a high CCI were also significantly associated with poor outcome. Focusing on preoperative optimization and peri/postoperative care in this group of patients is warranted to improve the outcome. Using frailty as a predictive measure for outcomes in emergency surgery has been shown to be important, and multiple tools have been developed and validated to this end; however, these tools have yet to be routinely incorporated into preoperative care. Frailty assessment permits the identification of high-risk patients, raises awareness of the treatment team regarding the need to customize procedural and medication choices, and allows pre-emptive planning for nutrition, reconditioning, recovery support, and post-discharge arrangements[19].

Improved objective tools are advocated to assess the preoperative condition of patients with emergency colonic cancer, such as blood investigations and cardiopulmonary monitoring charts. These tools can be combined with data about preoperative medications, laparoscopic intervention films, CT, and patient records to accurately assess preoperative status. Better preoperative assessment using information technologies will improve preoperative optimization and survival rates in this frail group of patients.

This population-based study investigated a large homogenous cohort. Data were collected prospectively and evaluated annually for completeness and accuracy by the DCCG steering committee; however, this study is subject to some limitations, such as missing values in some of the demographic data. Data about preoperative rehabilitation and postoperative enhanced recovery pathways were not available. Modifiable risk factors could not be identified. Long-term outcomes, such as disease-free survival and overall survival, were not reported. Moreover, the study extends over a long interval, during which many advances in surgical techniques and oncological management occurred.

More research is needed to investigate the effect of preoperative optimization in this group of patients.

Funding

The authors have no funding to declare.

Acknowledgements

The authors thank the DCCG for permission to use its data. N. H. Bruun's advice has been useful in the statistical analysis. The authors also thank O. F. AlSatam Alraoui, M. Ulanowskaa, P. C. Schroeder, and Z. Ahengar for their help in preparing the data file. A.E was responsible for study conception, study design and data retrieval. Statistical analysis was conducted by A.E. and M.K. All authors contributed to writing the manuscript and revising the drafts. *OpenSourceResearch* is an international organization with a special focus on implementing information technologies and artificial intelligence in clinical research. This study will be background material for other studies that the organization is planning to conduct, as shown on its website https://www.osrc.network.

Disclosure

The authors declare no conflict of interest.

Supplementary material

Supplementary material is available at *BJS Open* online.

Data availability

Due to ethical concerns the supporting data cannot be made openly available. Further information about the data and conditions for access are available upon request.

References

1. Arnold M, Rutherford MJ, Bardot A, Ferlay J, Andersson TML, Myklebust TÅ *et al.* Progress in cancer survival, mortality, and incidence in seven high-income countries 1995–2014 (ICBP SURVMARK-2): a population-based study. *Lancet Oncol* 2019;**20**:1493–1405
2. Hansen IO, Jess P. Possible better long-term survival in left versus right-sided colon cancer: a systematic review. *Dan Med J* 2012;**59**:A4444
3. Lee GH, Malietzis G, Askari A, Bernardo D, Al-Hassi HO, Clark SK. Is right-sided colon cancer different to left-sided colorectal cancer?: a systematic review. *Eur J Surg Oncol* 2015;**41**:300–308
4. Jess P, Hansen IO, Gamborg M, Jess T, Danish Colorectal Cancer Group. A nationwide Danish cohort study challenging the categorisation into right-sided and left-sided colon cancer. *BMJ Open* 2013;**3**:e002608
5. Baran B, Mert Ozupek N, Yerli Tetik N, Acar E, Bekcioglu O, Baskin Y. Difference between left-sided and right-sided colorectal cancer: a focused review of literature. *Gastroenterology Res* 2018;**11**:264–273
6. Boeding JRE, Ramphal W, Rijken AM, Crolla RMPH, Verhoef C, Gobardhan PD *et al.* A systematic review comparing emergency resection and staged treatment for curable obstructing right-sided colon cancer. *Ann Surg Oncol* 2021;**28**:3545–3555
7. Biondo S, Gálvez A, Ramírez E, Frago R, Kreisler E. Emergency surgery for obstructing and perforated colon cancer: patterns of recurrence and prognostic factors. *Tech Coloproctol* 2019;**23**:1141–1161
8. Wanis KN, Ott M, van Koughnett JAM, Colquhoun P, Brackstone M. Long-term oncological outcomes following emergency resection of colon cancer. *Int J Colorectal Dis* 2018;**33**:1525–1532
9. Fahim M, Dijksman LM, van der Nat P, Derksen WJM, Biesma DH, Smits AB. Increased long-term mortality after emergency colon resections. *Colorectal Dis* 2020;**22**:1941–1948
10. Manceau G, Voron T, Mege D, Bridoux V, Lakkis Z, Venara A *et al.* Prognostic factors and patterns of recurrence after emergency management for obstructing colon cancer: multivariate analysis from a series of 2120 patients. *Langenbecks Arch Surg* 2019;**404**:717–729
11. *European Union of Medical Specialities (UEMS) Emergency Surgery*. https://www.uemssurg.org/divisions/emergency-surgery (accessed 21 November 2022)
12. Faucheron JL, Paquette B, Trilling B, Heyd B, Koch S, Mantion G. Emergency surgery for obstructing colonic cancer: a comparison between right-sided and left-sided lesions. *Eur J Trauma Emerg Surg* 2018;**44**:71–77
13. Askari A, Malietzis G, Nachiappan S, Antoniou A, Jenkins J, Kennedy R *et al.* Defining characteristics of patients with colorectal cancer requiring emergency surgery. *Int J Colorectal Dis* 2015;**30**:1329–1336
14. El-Hussuna A, Lytras T, Bruun NH, Klein MF, Emile SH, Qvist N. Extended right sided colon resection does not reduce the risk of colon cancer local-regional recurrence: nation-wide population-based study from Danish Colorectal Cancer Group Database. *Dis Colon Rectum* 2022; DOI: 10.1097/DCR.0000000000002358 [Online ahead of print]
15. Klein MF, Gögenur I, Ingeholm P, Njor SH, Iversen LH, Emmertsen KJ *et al.* Validation of the Danish Colorectal Cancer Group (DCCG.dk) database: on behalf of the Danish Colorectal Cancer Group. *Colorectal Dis* 2020;**22**:2057–2067
16. Pedersen CB, Gøtzsche H, Møller JØ, Mortensen PB. The Danish civil registration system. A cohort of eight million persons. *Dan Med Bull* 2006;**53**:441–449
17. Zattoni D, Christoforidis D. How best to palliate and treat emergency conditions in geriatric patients with colorectal cancer. *Eur J Surg Oncol* 2020;**46**:369–378
18. Taylor JC, Iversen LH, Burke D, Finan PJ, Howell S, Pedersen L *et al.* Influence of age on surgical treatment and postoperative outcomes of patients with colorectal cancer in Denmark and Yorkshire, England. *Colorectal Dis* 2021; DOI: 10.1111/codi.15910 [Online ahead of print]
19. Simon HL, de Paula T R, da Luz MM P, Nemeth SK, Moug SJ, Keller DS. Frailty in older patients undergoing emergency colorectal surgery: USA National Surgical Quality Improvement Program analysis. *Br J Surg* 2020;**107**:1363–1371