Check the placeEmergency resection or diverting stoma followed by elective resection in patients with colonic obstruction due to locally advanced cancer: a national cohort study

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Abstract
Aim: The aim was to assess long-term prognosis after emergency resection versus primary diverting stoma followed by elective tumour resection.

Method: A national-register-based cohort study with retrospective analysis of prospectively collected data was performed. All Swedish patients with non-metastatic obstructive locally advanced colon cancer treated with emergency resection or diverting stoma, followed by an elective resection, between 2007 and 2017 were included. The Kaplan–Meier method and Cox proportional hazards model were used to compare all-cause mortality between patients with emergency resection and elective right- and left-sided resection. The multivariable model was adjusted for year of diagnosis, age at diagnosis, sex, Charlson Comorbidity Index, American Society of Anesthesiologists class, tumour location and pN stage.

Results: In all, 751 patients with a tumour in the right colon and 700 patients with a tumour in the left colon were included. Emergency resection was more common in patients with right-sided colon tumours (681/751) than in patients with left-sided colon tumours (483/700). The 5-year overall survival in patients with right-sided tumours was 25% after emergency resection and 46% after diverting stoma followed by elective resection (log-rank test \( P = 0.001 \)). The corresponding numbers for patients with left-sided colon tumours were 40% and 64% (\( P < 0.001 \)). Emergency resection was independently associated with increased all-cause mortality in patients with left-sided tumour (hazard ratio 1.63, 95% CI 1.21–2.19) but not in patients with right-sided tumour (hazard ratio 1.21, 95% CI 0.80–1.81).

Conclusion: Diverting stoma followed by elective resection is associated with improved survival compared with emergency resection in patients with left-sided colonic obstruction due to locally advanced tumours.

Keywords
colon cancer, colonic obstruction, emergency resection, locally advanced tumour
INTRODUCTION

Obstructing colon cancer is a risk factor for poor prognosis and emergency surgery is associated with higher morbidity and mortality compared to elective resections [1, 2]. A staged treatment algorithm as an alternative to emergency resection, such as colonic stenting or diverting stoma followed by elective resection, have been suggested to improve long-term outcomes [3].

An obstructing tumour is often locally advanced, engaging surrounding organs and tissues in 19%-47% of patients [4–7]. Preoperative investigations including staging and a multidisciplinary team conference are essential to optimize treatment, including neoadjuvant chemotherapy and planning the surgery. The physical condition of patients with colonic obstruction is often affected by malnutrition, dehydration, age and comorbidities, which could partly explain the poorer prognosis following emergency resection [8]. Whether emergency resection increases the risk of a suboptimal oncological, non-radical resection has been discussed but not yet proven [4].

An alternative to relieve the emergent colonic obstruction is a diverting stoma in the acute setting. This enables improved local and distant tumour staging, pre-habilitation, patient optimization and neoadjuvant treatment if indicated before an elective resection. Current research on the management of malignant colonic obstruction mainly compares emergency resection to colonic stenting as a bridge to later resection [9, 10]. Research on primary diverting stoma followed by elective resection compared with emergency resection is scarce.

The primary aim of this national study was to evaluate whether a diverting stoma followed by elective right-sided or left-sided resection improves overall survival compared with emergency resection in patients with obstructive, locally advanced colon cancer.

MATERIALS AND METHODS

National registers

The Swedish healthcare service is tax-funded and available to all residents. All Swedes are assigned a unique personal identification number, which enables linkage between healthcare registers.

The Swedish Colorectal Cancer Register (SCRCR) is a national quality register on all patients diagnosed with colorectal cancer. Data on patient and tumour characteristics are reported prospectively as well as perioperative data and postoperative histopathology. The national coverage was 94% in 2007 and had increased to 97% in 2017 [11, 12].

The National Patient Register (NPR) collects data on inpatient care and hospital-based outpatient visits with a national coverage of more than 99% [13].

The Swedish Cancer Register is a national register on all patients diagnosed with any type of primary cancer since 1958. Deaths, dates of death and causes of death are registered in the Causes of Death Register [14].

Patients

Data from the SCRCR and NPR were retrieved on all patients registered with colon cancer in Sweden between 2007 and 2017. A total of 8429 patients with a colon resection due to a primary locally advanced tumour (pT4) were identified. Figure 1 illustrates the retrieval of patients from the registers. Exclusion criteria were metastatic disease, preoperative colonic stent, polypectomy, synchronous locally advanced tumours, missing information on emergency/elective resection or tumour location emergency resection for other reasons than obstruction (such as ischaemia, perforation and intestinal bleeding) and elective resection without previous colonic obstruction treated with diverting stoma. The final study population included patients with non-metastatic locally advanced colon cancer and comprised 1451 patients.

Emergency resection was defined as unplanned surgery performed due to an emergent medical condition. Right-sided tumours included tumours from the caecum to the transverse colon. Left-sided tumours included tumours from the splenic flexure to the sigmoid colon. Comorbidity was classified according to the American Society of Anesthesiologists (ASA) score and the Charlson Comorbidity Index (CCI), which was further categorized into CCI 0, 1 and 2+ [15–17]. No points were given for previous colorectal cancer. Age was defined as the age of the patient at the time of cancer diagnosis and dichotomized into ≤70 and ≥70 years old. Histopathological nodal stage (pN) was determined in the postoperative histopathology report according to the TNM classification and collected from the SCRCR.

Information on comorbidities within a 5-year time window prior to diagnosis was obtained from main and secondary diagnosis codes (according to the International Classification of Diseases 10, ICD-10) as registered in the NPR. Additionally, the Swedish Cancer Register was used to ascertain previous cancer diagnoses. Type of diverting stoma in the emergency resection was defined according to the Nordic Medico-Statistical Committee (NOMESCO) Classification of Surgical Procedures (Table S1).
FIGURE 1  Flowchart of inclusions and exclusions

Patients with a colon resection due to a primary pT4 tumor 2007-2017
n=8,429

Exclusions (SCCR)
55 pat. Not reg. as emergency/elective resection.
375 pat. Emergency res. for other reasons than obstr.

Resected pT4 patients without distant metastases, 2007-2017
n = 5,492

Exclusions (SCCR)
2411 pat. Preop. signs of metastatic disease.
1 pat. Registered as polypectomy
95 pat. Preoperative colonic stent

Exclusions (NPR)
466 pat. Registered with stoma at the resection or later
28 pat. Elective res. with stoma >30d before res.
8 pat. Elective res. with stoma >90 days after diagn.

Final cohort
n = 1,451

Patients with a tumour in the right colon
n=751

Patients with a tumour in the left colon
n=700

Patients with diverting stoma and later elective tumour resection
n= 70

Patients with emergency tumour resection
n=681

Patients with diverting stoma and later elective tumour resection
n= 217

Patients with emergency tumour resection
n=483
Statistical analysis

Counts and percentages of patient and tumour characteristics were calculated by elective/emergency resection and divided in two groups depending on tumour location right/left (Table 1). Logistic regression was used for group comparisons (Tables 1 and 2). Postoperative mortality following tumour resection after 30 and 90 days was calculated in both groups. For the survival analyses, time since resection was used as the underlying time scale. Patients started being at risk at the time of resection and were followed until death or last follow-up (25 October 2018). There was no loss to follow-up or migration during the study period. The minimum follow-up time was 10 months.

Follow-up was restricted to the first 6 years after tumour resection. Cumulative survival was obtained using the Kaplan–Meier method (Figure 2). Colon-cancer-specific mortality was calculated based on the underlying cause of death information (ICD-10 codes C18.0, C18.2–9, C19.9 and C20.9) in the Swedish Cause of Death Register (Table S4). Hazard ratios (HRs) and 95% confidence intervals comparing all-cause mortality rates between patients with emergency and elective resections were estimated using Cox regression models. Both univariable and multivariable models (adjusted for sex, age at diagnosis, year of diagnosis, CCI score, ASA grade, tumour location, pN stage, university hospital and surgical competence) were fitted. The assumption of proportional hazards was formally tested using the Grambsch and Therneau test of Schoenfeld's residuals [18]. All models were complete case based, meaning that patients with missing information on any of the variables in the model were excluded from analysis. To investigate if the improved overall survival in the diverting stoma group was an effect of postoperative mortality alone, a conditional survival analysis was performed, where patients who died within 30 days after tumour resection were excluded. All analyses were performed using Stata version 15 software (StataCorp, College Station, Texas, USA). The study was approved by the Regional Ethical Review Board in Stockholm (2015/1390-31, 2017/2005-32 and 2018/673-32).

RESULTS

Between 2007 and 2017 a total of 751 patients with obstructing right-sided colon cancer and 700 patients with obstructing left-sided colon cancer were identified.

Patient and surgical characteristics in right-sided colon cancers

Of the patients with right-sided tumours, 681 patients (90.7%) were treated with emergency resection and 70 patients (9.3%) with diverting stoma followed by elective resection (Table 1). Median follow-up time was 18 months (interquartile range [IQR] 8–38) in the emergency resection group and 24 months (IQR 16–42) in the diverting stoma group (total follow-up time 1503 years). The median age at the time of colon cancer diagnosis in these patients was 76 years (range 22–98) for patients in the emergency resection group and 69 years (range 27–85) in the diverting stoma group (i.e., diverting stoma followed by elective tumour resection). The patients in the emergency resection group had a higher grade of comorbidity according to the CCI. Stoma after tumour resection was reported in 19/70 patients (27.1%) in the diverting stoma group and in 100/681 patients (14.7%) in the emergency resection group (Table S2). The tumour resections in the diverting stoma group were performed by a colorectal surgeon in 97.1% and in 73.9% after emergency resection. The laparoscopic approach was used in 1.5% of the patients in the emergency resection group and 1.4% of the patients in the diverting stoma group. The most commonly resected adjacent organ was adherent bowel, including duodenum, small and large bowel, in both groups (8.5% in the emergency resection group and 18.6% in the diverting stoma group). Most patients in the diverting stoma group had an ileostomy. There was no significant difference in anastomotic leakage or other postoperative complications between the groups (Table S3).

Patient and surgical characteristics in left-sided colon cancers

Patients with left-sided tumours were more often treated with emergency resection (69%) than diverting stoma followed by elective resection (31.0%, Table 1). Median follow-up time was 31 months (IQR 15–56) in the emergency resection group and 40 months (IQR 24–71) in the diverting stoma group (total follow-up time 1983 years). These patients had a median age of 73 years (range 29–99) in the emergency resection group and 69 years (range 26–90) in the diverting stoma group. The patients in the emergency resection group had more comorbidities. Stoma after tumour resection was reported in 145/217 patients (66.8%) in the diverting stoma group and in 259/483 patients (53.6%) in the emergency resection group (Table 2). Most of the tumour resections in the diverting stoma group were performed by a colorectal surgeon (99.5%). The laparoscopic approach was used in 5.1% of the patients in the diverting stoma group and in none of the patients in the emergency resection group. The pN stage was higher and the number of harvested lymph nodes lower in the emergency resection group. Adherent bowel was the most commonly resected adjacent organ (8.5% in the emergency resection group and 30% in the diverting stoma group). The most common type of diverting stoma in the emergency setting was transverse colostomy (48.8%). There was no significant difference in postoperative complications between the groups (Table S3).

Survival analysis

The patients with right-sided tumours had a 30-day and 90-day mortality of 52/681 (7.6%) and 91/681 (13.4%), respectively, in the
|                          | Right colon                                      |               | Left colon                                      |               |
|--------------------------|--------------------------------------------------|---------------|-----------------------------------------------|---------------|
|                          | Diverting stoma and later resection               | Emergency resection | OR (95% CI) | P value | Diverting stoma and later resection | Emergency resection | OR (95% CI) | P value |
| Total row (%)            | 70 (9.3)                                         | 681 (90.7)    | 217 (31.0)                                    | 483 (69.0)    |  |
| Year of diagnosis        |                                                  |               |                                               |               |
| 2007–2010                | 7 (10.0)                                         | 157 (23.1)    | 64 (29.5)                                     | 104 (21.5)    | 1.00 | 0.002 |
| 2011–2014                | 19 (27.1)                                        | 308 (45.2)    | 70 (32.3)                                     | 223 (46.2)    | 1.96 | (1.30–2.96) |
| 2015–2017                | 44 (62.9)                                        | 216 (31.7)    | 83 (38.3)                                     | 156 (32.3)    | 1.16 | (0.77–1.74) |
| Median age               | 69 (27–85)                                       | 76 (22–98)    | 69 (26–90)                                    | 73 (29–99)    | <0.001 |
| Age at diagnosis         |                                                  |               |                                               |               |
| <70                      | 37 (52.9)                                        | 193 (28.3)    | 112 (51.6)                                    | 193 (40.0)    | 1.00 | 0.004 |
| >70                      | 33 (47.1)                                        | 488 (71.7)    | 105 (48.4)                                    | 290 (60.0)    | 1.60 | (1.16–2.21) |
| Sex                      |                                                  |               |                                               |               |
| Male                     | 35 (50.0)                                        | 291 (42.7)    | 126 (58.1)                                    | 244 (50.5)    | 1.00 | 0.064 |
| Female                   | 35 (50.0)                                        | 390 (57.3)    | 91 (41.9)                                     | 239 (49.5)    | 1.36 | (0.98–1.87) |
| Charlson Comorbidity     |                                                  |               |                                               |               |
| Index (CCI)              |                                                  |               |                                               |               |
| 0                        | 55 (78.6)                                        | 421 (61.8)    | 157 (72.4)                                    | 319 (66.1)    | 1.00 | 0.253 |
| 1                        | 6 (8.6)                                          | 111 (16.3)    | 24 (11.1)                                     | 67 (13.9)     | 1.37 | (0.83–2.27) |
| 2+                       | 9 (12.9)                                         | 149 (21.9)    | 36 (16.6)                                     | 97 (20.1)     | 1.33 | (0.86–2.03) |
| ASA score                |                                                  |               |                                               |               |
| 1                        | 11 (15.7)                                        | 63 (9.3)      | 32 (14.8)                                     | 52 (10.8)     | 1.00 | <0.001 |
| 2                        | 32 (45.7)                                        | 280 (41.1)    | 119 (54.8)                                    | 218 (45.1)    | 1.27 | (0.69–1.85) |
| 3                        | 26 (37.1)                                        | 287 (42.1)    | 59 (27.2)                                     | 186 (38.5)    | 1.94 | (1.14–3.29) |
| 4                        | 1 (1.4)                                          | 34 (5.0)      | 4 (1.8)                                       | 14 (2.9)      | 2.15 | (0.65–7.12) |

(Continues)
The 30-day and 90-day mortality in patients with left-sided tumours were 20/483 (4.1%) and 36/483 (7.5%), respectively, in the emergency group. Equivalent figures in the diverting stoma group were 2/217 (0.9%) and 5/217 (2.3%), respectively.

Patients in the diverting stoma group had a superior overall survival compared to patients in the emergency resection group regardless of tumour location (Figure 2a,b). The patients with right-sided tumours had a 5-year overall survival of 46% in the diverting stoma group and 25% in the emergency resection group. The 5-year overall survival for the patients with left-sided tumours was 40% in the emergency resection group and 64% in the diverting stoma group.

There was no significant association between emergency resection and all-cause mortality (HR 1.21, 95% CI 0.80–1.81) in patients with right-sided tumours in the multivariable model (Table 3). Emergency resection in patients with left-sided tumours was associated with a higher all-cause mortality (HR 1.63, 95% CI 1.21–2.19). The results were unchanged when a maximum follow-up time (until 25 October 2018) was used.

Similar results were received from analyses of colon-cancer-specific mortality (HR 0.94, 95% CI 0.60–1.47 in patients with right-sided tumours and HR 1.55, 95% CI 1.11–2.17 in patients with left-sided tumours, Table S4). Emergency resection was associated with higher mortality for patients with left-sided tumours in the conditional survival analysis (HR 1.58, 95% CI 1.18–2.11). The corresponding numbers for patients with right-sided tumours were HR 1.33, 95% CI 0.89–2.01.

**DISCUSSION**

This national cohort study shows that the surgical strategy in patients with obstructing locally advanced colon cancer is associated with long-term survival. In patients with left-sided obstructing colon cancer, treatment with a diverting stoma followed by elective resection was associated with an improved overall survival, compared with emergency resection. To our knowledge this is the first study restricted to colonic obstruction in locally advanced colon cancer.

Emergency surgery of obstructive colon cancer is associated with high morbidity and a high short-term mortality; 10% after emergency surgery versus 3.5% after elective surgery [19]. Staged resection with diverting stoma followed by elective resection has been discussed but there are no available clinical trials and few population-based cohort studies comparing this approach with emergency resection. Earlier studies have presented a 5-year overall survival of 39%–50% after emergency surgery for patients with non-metastatic disease [1, 5, 20]. A recent propensity-score-matched study presented a lower 90-day mortality (1.7% vs. 7.2%, P = 0.006) and better 3-year overall survival (79.4% vs. 73.3%) compared to emergency resection in patients with left-sided obstructive colon cancer [21]. This study was restricted to patients without locally advanced disease. A study on obstructive or perforated colon cancer...
presented a 5-year overall survival of 69% [22]. However, since they included pT1–T4 colon cancer and excluded 15% of the patients who died postoperatively, the numbers are not comparable with the present study.

To account for differences in tumour biology and surgical approach between right-sided and left-sided tumours, we chose to only present stratified results. In the present study, the 5-year overall survival was improved in patients with left-sided colon cancer who had received a diverting stoma followed by elective resection (64%) compared with those who underwent emergency resection (40%). These numbers are in line with a study of pT2–T4 left-sided colon and rectal cancers reporting a better 5-year overall survival after diverting stoma (67%) than after emergency resection (44%) [6]. Another study of Stage II–IV left-sided malignant colonic obstruction showed that the 5-year overall survival increased more following segmental colectomy (67%) than after diverting colostomy (54%), but the latter group included unresectable tumours and Stage IV disease, which makes the groups non-comparable [23].

Resection of the right colon is also considered less complex than surgery of the left colon. In the current study, multivisceral resection

| TABLE 2 Surgical and histopathological characteristics in 1451 patients with colon obstruction due to locally advanced colon cancer in Sweden (2007–2017) |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| Right colon                                     | Left colon                                      |
| Diverting stoma and later resection             | Diverting stoma and later resection             |
| Emergency resection                            | Emergency resection                            |
| OR (95% CI)                                     | OR (95% CI)                                     |
|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| No. of harvested lymph nodes (median)           | No. of harvested lymph nodes (median)           |
| Right colon                                     | Left colon                                      |
|-----------------------------------------------|-----------------------------------------------|
| Radical                                       | Radical                                       |
| No                                            | No                                            |
| 28 (4–99)                                     | 24.5 (3–99)                                   |
| Emergency resection                            | Emergency resection                            |
| No                                            | No                                            |
| 20 (2–99)                                     | 20 (0–96)                                     |
| OR (95% CI)                                    | OR (95% CI)                                    |
| Radical                                       | Radical                                       |
| No                                            | No                                            |
| 60 (85.7)                                     | 201 (92.6)                                   |
| Emergency resection                            | Emergency resection                            |
| No                                            | No                                            |
| 587 (86.2)                                    | 438 (90.7)                                   |
| Radical                                       | Radical                                       |
| No                                            | No                                            |
| 9 (12.9)                                      | 14 (6.5)                                     |
| Emergency resection                            | Emergency resection                            |
| No                                            | No                                            |
| 91 (13.4)                                     | 43 (8.9)                                     |
| Radical                                       | Radical                                       |
| No                                            | No                                            |
| 1 (1.4)                                       | 2 (0.9)                                      |
| Emergency resection                            | Emergency resection                            |
| No                                            | No                                            |
| 3 (0.4)                                       | 2 (0.4)                                      |
| pN stage                                       | pN stage                                       |
| N0                                            | N0                                            |
| 21 (30.0)                                     | 96 (44.2)                                   |
| Emergency resection                            | Emergency resection                            |
| No                                            | No                                            |
| 161 (23.6)                                    | 141 (29.2)                                   |
| Stoma at tumour resection                      | Stoma at tumour resection                      |
| No                                            | No                                            |
| 51 (72.9)                                     | 72 (33.2)                                   |
| Yes                                           | Yes                                           |
| 19 (27.1)                                     | 145 (66.8)                                   |
| Stoma at tumour resection                      | Stoma at tumour resection                      |
| No                                            | No                                            |
| 581 (85.3)                                    | 224 (46.4)                                   |
| Yes                                           | Yes                                           |
| 100 (14.7)                                    | 259 (53.6)                                   |
| Highest surgical competence                   | Highest surgical competence                   |
| Colorectal surgeon                             | Colorectal surgeon                             |
| 68 (97.1)                                     | 503 (73.9)                                   |
| General surgeon                               | General surgeon                               |
| 1 (1.4)                                       | 169 (24.8)                                   |
| Resident                                       | Resident                                       |
| –                                             | 2 (0.3)                                      |
| Missing                                        | Missing                                        |
| 1 (1.4)                                       | 7 (1.03)                                     |
| University hospital                            | University hospital                            |
| 28 (40.0)                                     | 199 (29.2)                                   |
| Other hospital                                 | Other hospital                                 |
| 42 (60.0)                                     | 482 (70.8)                                   |
| Admission                                     | Admission                                     |
| Yes                                           | Yes                                           |
| 39 (55.7)                                     | 262 (38.5)                                   |
| No                                            | No                                            |
| 19 (27.1)                                     | 324 (47.6)                                   |
| Missing                                        | Missing                                        |
| 12 (17.1)                                     | 95 (14.0)                                     |

Note: Odds ratios for emergency resection were calculated for both groups.

aNo missing values.

bWith the reservation that the number of patients actually starting and fulfilling treatment is unknown.
was less common in patients with right-sided tumours and an emergency resection was possibly not as demanding as in the left colon. There are several possible benefits with a diverting stoma followed by elective resection. Emergency resection of obstructive colon cancer does not necessarily have to be complicated, but the surgery can be very demanding when the tumour is locally advanced. The strategy with diverting stoma followed by elective resection offers the possibility of optimizing both the patient and the surgical team. All patients with right-sided tumours and almost all patients with left-sided tumours who received a stoma followed by elective resection were discussed at a preoperative multidisciplinary team conference (Table S2).

A high number of harvested lymph nodes, in addition to a radical resection, is crucial for survival in patients with colon cancer [24]. In our study, the median number of harvested lymph nodes was higher in the stoma group than in the emergency resection group. The majority of the elective tumour resections were performed by colorectal surgeons, whereas the corresponding numbers after emergency resection were much lower, which may explain the differences in the number of harvested lymph nodes. The presence of higher surgical competence at the tumour resection may also contribute to the improved outcome in the stoma group.

Another possible benefit is the option of neoadjuvant chemotherapy, which has recently been shown to improve oncological
| TABLE 3 | Hazard ratios (HRs) with 95% confidence intervals (CIs) presenting the all-cause mortality at 5 years after diagnosis |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| | Right colon | | | Left colon | | | | | | | | | | |
| | Univariable | Multivariable | | | Univariable | Multivariable | | | | | | | |
| | HR | 95% CI | P value | HR | 95% CI | P value | HR | 95% CI | P value | HR | 95% CI | P value | |
| Type of resection | | | | | | | | | | | | | |
| Elective | 1 | <0.001 | 1 | 0.365 | | | | | | | | |
| Emergency | 1.86 | 1.27-2.73 | 1.21 | 0.80-1.81 | | | | | | | | |
| Sex | | | | | | | | | | | | | |
| Male | 1 | 0.814 | 0.653 | | | | | | | | | |
| Female | 1.02 | 0.85-1.22 | 1.04 | 0.87-1.26 | | | | | | | | |
| Age at diagnosis | | | | | | | | | | | | | |
| <70 years | 1 | <0.001 | 1 | 0.365 | | | | | | | | |
| ≥70 years | 1.60 | 1.31-1.97 | 1.44 | 1.15-1.81 | | | | | | | | |
| Year of diagnosis | | | | | | | | | | | | | |
| 2007-2010 | 1 | <0.001 | 0.003 | | | | | | | | | |
| 2011-2014 | 0.95 | 0.77-1.18 | 0.86 | 0.68-1.07 | | | | | | | | |
| 2015-2017 | 0.64 | 0.50-0.83 | 0.63 | 0.48-0.82 | | | | | | | | |
| Charlson Comorbidity Index, CCI | | | | | | | | | | | | | |
| 0 | 1 | <0.001 | 1 | 0.303 | | | | | | | | |
| 1 | 1.31 | 1.02-1.68 | 1.04 | 0.79-1.36 | | | | | | | | |
| 2+ | 1.55 | 1.25-1.93 | 1.21 | 0.95-1.54 | | | | | | | | |
| ASA class | | | | | | | | | | | | | |
| 1 | 1 | <0.001 | 1 | <0.001 | 1 | <0.001 | 1 | | | | | |
| 2 | 0.96 | 0.69-1.32 | 0.85 | 0.61-1.18 | 1.01 | 0.68-1.50 | 0.99 | 0.66-1.50 | | | | |
| 3 | 1.41 | 1.03-1.94 | 1.42 | 1.01-1.99 | 1.94 | 1.31-2.89 | 1.63 | 1.06-2.50 | | | | |
| 4 | 2.52 | 1.58-4.02 | 3.31 | 2.00-5.48 | 3.69 | 1.96-6.96 | 2.40 | 1.23-4.72 | | | | |
| 5 | 20.71 | 2.79-153.40 | 7.65 | 1.00-58.33 | 15.23 | 4.59-50.50 | 10.55 | 3.06-36.38 | | | | |
| pN stage | | | | | | | | | | | | | |
| pN0 | 1 | <0.001 | 1 | <0.001 | 1 | <0.001 | 1 | | | | | |
| pN1 | 1.75 | 1.33-2.31 | 1.98 | 1.49-2.64 | 1.53 | 1.15-2.03 | 1.45 | 1.08-1.95 | | | | |
| pN2 | 2.66 | 2.06-3.42 | 3.41 | 2.61-4.46 | 2.41 | 1.81-3.21 | 2.73 | 2.02-3.67 | | | | |
| University hospital | 0.004 | | | | | | | | | | | |

(Continues)
outcomes in locally advanced colon cancer [25, 26]. Neoadjuvant chemotherapy can result in downstaging and tumour regression in patients with obstructing or high risk colon cancer [27–30]. In the present study, 24% of the patients with right-sided colon cancer and 29% of the patients with left-sided colon cancer that were diverted received neoadjuvant chemotherapy. According to recent national guidelines, neoadjuvant treatment should be offered to younger patients with a biological age <75 years, which indicates that 50% of the patients in our study should nowadays be offered neoadjuvant treatment [31].

Colonic stent followed by elective resection has been an alternative to treat obstructive tumours, especially in the left colon. However, outcomes are inconsistent considering complications and survival rates in this group. Survival rates similar to those after diverting stoma followed by elective resection have been reached [32]. It is a method associated with less morbidity if successful, but there is also a substantial risk for perforation. Due to previously reported complications from colonic stent, this method was mainly used as palliative treatment in Sweden during the time period of the current study [33, 34].

The strengths of this study include the population-based design and nationwide coverage with complete follow-up through national registers. This enables the results to be generalized to other countries with similar populations and healthcare structures. Additionally, the study was restricted to patients with locally advanced tumours, that is, those who may benefit most from defunctioning at the time of the emergent obstruction, with subsequent evaluation and possible neoadjuvant chemotherapy.

A limitation is that we cannot know the reasons for the surgeons’ strategies and whether the decision to resect/divert was taken preoperatively or during surgery. One could expect that a surgeon would prefer to perform emergency surgery in a healthier patient. On the other hand, it is possible that the surgeon believed that an older patient, with comorbidity and shorter life expectancy, would be better off with only one operation, and that the oncological result in this patient was of less importance. Fewer lymph nodes were harvested in the emergency cohort, supporting this theory. To adjust for this heterogeneity between the two groups, we adjusted our models for age and two measures of comorbidity (ASA and CCI) in the multivariable model. Despite these adjustments, there is a potential risk of residual confounding. As this was a register-based study, there was no access to specific data from patient files.

It would have been preferable to use the preoperative clinical tumour stage (cT4) as an inclusion criterion but only 25% of our patients had a cT4 reported in the SCRCR that corresponded with their pT stage (data not shown). The remaining 75% were either not staged before surgery or had a cT stage that did not correspond with the pT stage. To ensure that we studied a homogeneous group we used the pathological tumour stage (pT4) as an inclusion criterion and excluded patients who received palliative treatment and/or did not have their tumour resected.
CONCLUSION

In this nationwide population-based study, treatment with diverting stoma followed by elective tumour resection was associated with improved overall survival in patients with left-sided obstructive locally advanced colon cancer, compared to emergency resection. To further evaluate the method, a randomized clinical trial needs to be performed.

ETHICAL APPROVAL

The study was approved by the Regional Ethical Review Board in Stockholm (2015/1390-31, 2017/2005-32 and 2018/673-32).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

All authors have contributed to the work of the article.

DATA AVAILABILITY STATEMENT

Research data are not shared.

DISCLAIMERS

None.

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SUPPORTING INFORMATION

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

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