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Role of Emergency Laparoscopic Colectomy for Colorectal Cancer: A Population-Based Study in England

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Running head: Laparoscopy for emergency colectomy

MINI-ABSTRACT

This population-based cohort study including 15,516 patients undergoing emergency colorectal cancer resection in the English National Health Service, found hospital length of stay was shorter and 90-day mortality was lower in patients having a laparoscopic approach compared to patients undergoing open surgery.

STRUCTURED ABSTRACT

Objective: To evaluate factors associated with the use of laparoscopic surgery and the associated post-operative outcomes for urgent or emergency resection of colorectal cancer in the English National Health Service.

Summary Background Data: Laparoscopy is increasingly used for elective colorectal cancer surgery, but uptake has been limited in the emergency setting.

Methods: Patients recorded in the National Bowel Cancer Audit who underwent urgent or emergency colorectal cancer resection between April 2010 and March 2016 were included. A multivariable multilevel logistic regression model was used to estimate odds ratios (OR) of undergoing laparoscopic resection, and post-operative outcome according to approach.

Results: There were 15,516 patients included. Laparoscopy use doubled from 15.1% in 2010 to 30.2% in 2016. Laparoscopy was less common in patients with poorer physical status (ASA 4/5 vs. 1, OR 0.29 (95% CI 0.23-0.37), $P < 0.001$) and more advanced T-stage (T4 vs. T0-T2, OR 0.28 (0.23-0.34), $P < 0.001$) and M-stage (M1 vs. M0, OR 0.85 (0.75-0.96), $P < 0.001$). Age, socioeconomic deprivation, nodal stage, hospital volume, and a dedicated colorectal emergency service, were not associated with laparoscopy. Laparoscopic patients had a shorter length of stay (median 8 days (interquartile range (IQR) 5-15) vs. 12 (IQR 8-21), adjusted mean difference -3.67 (-4.60--2.74), $P < 0.001$) and lower 90-day mortality (8.1% vs. 13.0%; adjusted OR 0.78 (0.66-0.91), $P = 0.004$) than patients undergoing open resection. There was no significant difference in rates of readmission or reoperation by approach.

Conclusions: The use of laparoscopic approach in the emergency resection of colorectal cancer is linked to a shorter length of hospital stay and reduced postoperative mortality.

INTRODUCTION

Almost one in five colorectal cancer patients in the United Kingdom are diagnosed when presenting for emergency resection, a risk factor for a poor outcome¹⁻³. The National Bowel Cancer Audit (NBOCA), a national evaluation of bowel cancer services in the English National Health Service (NHS), reports that post-operative mortality after emergency colorectal cancer resection are considerably higher than those following elective surgery³. Efforts directed at minimising the operative ‘insult’ to patients undergoing an emergency colorectal cancer resection are therefore required^{4,5}.

Laparoscopic surgery has gained wide acceptance as an alternative to open surgery in the management of uncomplicated colorectal disease. In many centres, the laparoscopic approach is now the standard of care in elective colorectal cancer surgery, and is associated with a reduction in post-operative pain, respiratory complications, wound complications and in-patient hospital stay⁶⁻⁸. Although emergency laparoscopic surgery may lead to similar benefits in appropriately selected patients, the uptake of laparoscopic surgery in this setting has been limited. Patients requiring emergency surgery typically present systemically unwell and with often complex intra-abdominal pathology, which could make laparoscopic surgery technically more challenging⁹.

There are no published randomised trials comparing surgical access for colorectal cancer resection in the emergency setting. Retrospective cohort and case-control studies have reported that the laparoscopic approach for colorectal cancer resection used in an emergency setting is safe and that it is associated with shorter length of hospital stay and lower post-operative morbidity than an open approach¹⁰⁻¹³. However, these are single institution analyses, have limited patient numbers and tend to be conducted at centres where surgeons carry out relatively high numbers of laparoscopic procedures. The results of these studies may therefore not reflect treatment outcomes among other lower volume hospitals. The three population-based studies of the use and outcomes of emergency laparoscopic colectomy carried out to date, include all colorectal pathology and are not limited to colorectal cancer

patients¹⁴⁻¹⁶. Thus, further study on the current state and outcomes of laparoscopic resection for colorectal cancer resection in the emergency setting is warranted.

The aim of this study was to evaluate the patient and institutional factors associated with the use of a laparoscopic approach and its post-operative outcomes for urgent and emergency resection of colorectal cancer in the English NHS.

METHODS

Patient selection

Patients with a primary colorectal cancer recorded in the NBOCA dataset who underwent an urgent or emergency colorectal cancer resection in an English NHS hospital trust from 1st April 2010 to 31st March 2016 were included (Figure 1). NBOCA collects data on all patients with newly diagnosed colorectal cancer in England and Wales, but for the purpose of this study only data on patients diagnosed in England were used. Data entry is prospective and mandatory.

Data sources

Data regarding surgical urgency, American Society of Anaesthesiologists (ASA) class, pathological staging, cancer site and surgical approach were obtained from NBOCA. Surgical urgency is classified in NBOCA data according to the National Confidential Enquiry into Patient Outcome and Death (NCEPOD) pre-2004 classification¹⁷. In this system, elective is defined as “operation at a time to suit both patient and surgeon e.g. after an elective admission”, scheduled as “early operation (usually within three weeks) but not immediately life-saving (this category often includes patients treated on cancer pathways with targets)”, urgent “operation as soon as possible after resuscitation and usually within 24 hours” and emergency as “immediate and life-saving operation, resuscitation simultaneous with surgical treatment with operation usually within two hours”.

NBOCA data were linked to the Hospital Episode Statistics (HES) database, an administrative database of all admissions to NHS trusts, to identify length of hospital stay, unplanned readmission,

place of discharge and return to the operating theatre. The Royal College of Surgeons Charlson Score was used to identify International Classification of Diseases, Version-10 (ICD-10) codes of comorbid conditions in HES included in the record of the hospital admission during which the operation took place or in records of admissions in the preceding year¹⁸. The Charlson Score represents the number of comorbid conditions. The date of death was obtained from linked data from the Office for National Statistics (ONS). Socioeconomic status was derived from the Index of Multiple Deprivation (IMD), an index capturing levels of deprivation in areas that cover around 1,500 people or 400 households¹⁹. Patients were grouped into five socioeconomic categories based on quintiles of the national ranking of these areas.

Data regarding the presence of a dedicated emergency colorectal service at a hospital trust were collected in January 2017 by a national electronic organisational survey carried out by the NBOCA team. This survey was completed by the colorectal cancer lead clinician with 15 out of 145 (10.3%) hospital trusts in England reporting a dedicated emergency colorectal service.

Comparison and outcome variables

Comparisons were made across laparoscopic and open surgical approaches. Patients who underwent unplanned intraoperative conversion from laparoscopic to open resection were included in the laparoscopic cohort in order to carry out an intention-to-treat analysis. The rate of conversion was recorded as an outcome measure. Length of stay was calculated as the date of admission to the date of discharge. The median length of stay (with interquartile range, IQR) was reported in an unadjusted analysis. The 90-day post-operative mortality was calculated from the date of colorectal cancer resection. An unplanned readmission was defined as an emergency admission to hospital within 30 days of major resection. Reoperation was defined as any return to theatre for an intra-abdominal procedure or wound complication on the index admission, or on a subsequent admission to hospital identified in the HES database within 30 days of the initial colorectal cancer resection. The codes used to define return to theatre were adapted from those used by Burns et al. (2012)²⁰. To examine the relationship between provider volume and use of laparoscopic surgery, the NHS hospital trusts were

divided into three groups of equal number based on number of study patients undergoing surgery in that trust during the 6-year study period.

Statistical analysis

Differences in patient characteristics between the laparoscopic and open cohorts were assessed using the χ^2 test. A multivariable multilevel logistic regression model was used to estimate odds ratios (OR) of undergoing laparoscopic resection by patient characteristics (age, sex, IMD in quintiles, comorbidities according to the Charlson Score, cancer site, T-stage, N-stage, M-stage) and hospital characteristics (volume in tertiles, presence of a dedicated colorectal emergency service). The multilevel logistic regression model to estimate OR of post-operative outcomes (90-day mortality, length of stay, 30-day readmission and 30-day reoperation) in patients undergoing a laparoscopic surgery included adjustment for these patient and hospital characteristics. Missing values for the risk factors were dealt with by multiple imputation using chained equations creating 10 data sets²¹. Rubin's rules were used to pool the regression coefficients and estimate their standard errors.

Stata version 14.1 (Stata Corp LLC, College Station, TX, US) was used for all statistical analyses.

RESULTS

Between 2010 and 2016, a total of 106,174 patients were diagnosed with colorectal cancer and underwent major resection in the English NHS. Of these, 16,790 (15.8%) were performed in an urgent or emergency manner. 15,516 had complete data regarding surgical access and were included in the analysis of surgical approach (Figure 1).

Surgical approach

Of these 15,516 resections, 3,435 (22.1%) started with a laparoscopic approach and 12,081 (78.9%) and started with an open approach. The proportion of laparoscopic resections doubled across the study period, from 15.1% (390/2,581) in 2011 to 30.3% (805/2,661) in 2016. Overall, 18.7% of

laparoscopic procedures (643/3,435) were converted to open. The rate of unplanned conversions did not increase across the study period, and was 19.7% (77/390) in 2011 and 14.5% (117/805) in 2016.

The patient characteristics by surgical approach are presented in Table 1. The patients in the laparoscopic group were younger than in the open group (age 18-64 years: 32.7% vs. 29.1%). There were no significant differences in socioeconomic status (IMD quintile) or the number of comorbidities (Charlson Score) between patients who had a laparoscopic or open approach. Patients who had a laparoscopic procedure were more likely to have a better physical status than those who had an open procedure (ASA class 1 or 2: 61.7% vs. 51.0%). Patients in the laparoscopic group more often had a caecal primary (41.4% vs. 35.7%) and rectal primary (9.8% vs. 4.8%), and less often left sided colon tumours (53.8% vs. 47.8%). Patients with a more advanced TNM stage tended to undergo an open resection. Those in the open cohort more commonly had T4 (59.1% vs. 44.0%), N2 (30.0% vs. 25.4%) and M1 (27% vs. 19%) cancer stage.

Table 1 also shows that slightly more patients who had laparoscopic surgery were treated in an NHS hospital trust with a dedicated colorectal emergency service than patients who had open surgery (15.2% vs. 12.0%). In addition, more patients who had laparoscopic surgery were treated in high-volume trusts than patients who had open surgery (highest tertile of volume: 35.6% vs. 32.1%).

Impact of patient and hospital characteristics on surgical approach

Multivariable logistic regression was used to adjust for possible correlation between the patient and institutional characteristics (Table 2). With this adjustment, we found that patients with a poor physical status and a more advanced T stage had a reduced chance of having laparoscopic approach, whereas a laparoscopic approach seemed now to be increased in patients with more comorbidities. The chance of having laparoscopic surgery was highest in patients with rectal cancer, although the number of rectal cancer resections was small.

Table 2 also shows that the chance of having an emergency laparoscopic procedure increased steadily over the study period. After adjustment, patients treated in high-volume hospital trusts and those treated in hospital trusts with a dedicated emergency colorectal service were not more likely to undergo laparoscopic resection.

Patient outcomes

The median length of stay for patients who had an open resection was 12 days (inter-quartile range (IQR) 8-21), compared to 8 days (IQR 5-14), ($P < 0.001$) for patients who had a laparoscopic resection (Table 3). This difference remained statistically significant when it was adjusted for differences in patient and institutional characteristics (adjusted mean difference in length of stay -3.67 days (95% CI -4.60 to -2.74)).

Patients who had laparoscopic surgery had lower 90-day mortality than those who had open surgery patients (8.5% vs. 13.9%) which remained statistically significant when it was adjusted for differences in patient and institutional characteristics (OR 0.78, 95% CI 0.66 to 0.91, $P < 0.001$).

The rate of 30-day unplanned readmission was slightly higher in patients who had laparoscopic surgery (9.5% vs 7.9%) and the rate of 30-day reoperation was slightly lower (7.6% vs. 8.6%), but both differences were no longer significant in the multivariable model.

Place of discharge according to surgical approach is displayed in Table 4. The rate of discharge to normal place of residence was higher in patients undergoing laparoscopic surgery (90.6% vs. 94.1%) (Table 4).

DISCUSSION

This population-based study, which is the largest performed to date investigating surgical approach for emergency colorectal cancer resection, demonstrates that the use of laparoscopic surgery in the emergency setting has steadily increased from 2010 to 2016. This has not coincided with an increase

in unplanned conversion to open surgery. We found that patients who had laparoscopic surgery had a shorter length of hospital stay and lower 90-day mortality.

The use of laparoscopic surgery in the emergency setting appears to have rapidly increased in the last decade. A study performed in NHS hospitals from 1996 to 2007 found that only 543 of 102,236 emergency major colorectal resections (0.6%) were performed laparoscopically¹⁵. A recent population-based study in the US of 22,719 patients who had emergency surgery between 2008 and 2011 found that 4.2% of patients had a laparoscopic approach²². These findings are in stark contrast to the present study which demonstrated that in 2016 a laparoscopic approach was used in over 30% of patients undergoing emergency colorectal cancer resection in English NHS hospitals. This may be explained by the introduction of the National Training Programme in laparoscopic surgery (Lapco) in 2007, which allowed UK-based surgeons to be formally trained in laparoscopic colorectal cancer resection under a module-based proctorship²³. This led to an expansion of laparoscopy across the UK and accelerated the experience of surgeons in a safe and regulated manner²⁴.

The results of the present study demonstrate that patients with advanced disease were more likely to have an open approach. Laparoscopic resection in patients with advanced stage colorectal cancer is oncologically adequate and has a shorter length of LOS, compared to open resection²⁵⁻²⁷. However, T4 tumours are often bulky which makes a laparoscopic approach more challenging due to lack of space in the abdomino-pelvic cavity and difficulty in delineating the anatomy to ensure a tumour-free resection margin.

This study is the first to examine the relationship between socioeconomic status and laparoscopic surgery specifically in the emergency resection of colorectal cancer resection, and found no association. This is in contrast to recent studies from both the United States²⁸⁻³⁰ and elsewhere in Europe³¹ for all patients with colorectal cancer demonstrating significant socioeconomic differences in access to minimally invasive techniques. This may suggest alternative patient and tumour related variables override socioeconomic status to guide surgical access in the acute setting.

Elderly patients are at increased risk of an emergency presentation of colorectal cancer³² and emergency surgery in this cohort is associated with a high morbidity and mortality^{33,34}. However, we found no difference in the use of laparoscopic surgery in older patients, after adjusting for their other characteristics. This, in concordance with a recent systematic review³⁵, suggests that the effect of physical status, rather than age, determined whether or not a laparoscopic approach was used. Elderly patients and those who are physiologically compromised often present a paradox. Whilst on one hand there is an urgency to correct the source of the problem without subjecting the patient to pneumoperitoneum and its effect on respiratory function and cardiovascular resistance, they are often the subset of patients who have the most to benefit from a minimally invasive approach. Our study demonstrated that a poor physical status, as captured with the ASA classification, strongly reduced the use of laparoscopic surgery whereas having two or more comorbidities seemed to increase it somewhat. This observed increase in the use of laparoscopic surgery should not be over-interpreted because it is partly a result of the correlation between a patient's physical status and the number of comorbidities. This may be explained by collinearity in the regression model³⁶.

In high-risk patients with a poor physical status, one could argue that a swift open approach may lead to better outcomes, particularly if the surgical treatment is carried by a less experienced surgeon⁹. Often patients who are at risk of respiratory complications and are displaying signs of progressing sepsis will not be suitable for a lengthy procedure involving a pneumoperitoneum. It has been shown that there is a higher risk of intra-operative conversion from a laparoscopic to an open approach in patients with poorer physical status³⁷. On the other hand, a recent Dutch population-based study of surgical approach in elective colorectal cancer resection found the largest reduction in absolute mortality rate linked to the use of laparoscopic surgery was in high-risk patients³⁸. This suggests that further investigation into the outcomes of laparoscopic surgery specifically in a high-risk emergency colorectal cancer population is warranted

There was no association between institutional factors such as hospital volume and the presence of a dedicated emergency colorectal service and utilisation of laparoscopic surgery when adjusted for differences of patient characteristics in our study. These results are in contrast to those reported from a study from North America showing that colorectal surgeons are more likely than general surgeons to perform urgent and emergency cases through a laparoscopic approach ²². Laparoscopy is well established as a default approach for elective colorectal cancer surgery in the UK and Europe, and there has not been a similar adoption in the US during this period which may explain why the use of laparoscopic surgery is limited to high-volume specialist centres.

We recognize the limitations in this study. For example, we have not been able to fully adjust for all differences in patient characteristics between patients who had a laparoscopic and those who had an open approach. Despite the use of a validated model developed specifically for prediction of post-operative mortality in colorectal cancer patients ³⁹, the use of such a model will not correct for the whole range of factors that may influence the decision to perform laparoscopic or open surgery. For example, the NBOCA data linked to the HES database did not include physiological and biochemical measures that are included in other prognostic models ⁴⁰. In addition, **we were not able to account for institutional differences in the utilisation of fast track, or enhanced recovery protocols, and information on neoadjuvant treatment and variations in laparoscopic technique (such as hand port assisted surgery)** was also not available.

In conclusion, **a large proportion of patients in England (15.8%) who undergo major resection for colorectal cancer, do so in the emergency setting. This study highlights the ongoing need to improve both the early detection of colorectal and the treatment outcomes in those who do undergo emergency surgery.** The use of a laparoscopic approach now accounts for almost one third of emergency colorectal cancer cases in the UK. This increased use of laparoscopy has not resulted in an increase in the rate of unplanned conversions to open surgery. Our finding that laparoscopic colorectal cancer resection in the emergency setting is linked to a shorter length of hospital stay and a lower postoperative mortality is an important addition to the literature.

TABLE AND FIGURE LEGENDS

Figure 1 Flow chart of patient inclusion and exclusion

Table 1 Patient and hospital characteristics according to surgical approach (N=15,516)

Table 2 Adjusted Odds ratio of undergoing laparoscopic major resection in 14,756 patients undergoing urgent/emergency surgery who could be linked to the organisational survey data.

Table 3 Observed and adjusted post-operative outcomes by surgical approach in the 12,996 patients with complete outcomes data

Table 4 Discharge location according to surgical approach (N=14,141) (excluding patients with in-hospital mortality)

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