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ORIGINAL ARTICLE

Risk of readmission after laparoscopic vs. open colorectal surgery

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Abstract
Purpose Laparoscopic colorectal resection (LC) is associated with known recovery benefits and earlier discharge when compared to open colorectal resection (OC). Whether earlier discharge leads to a paradoxical increase in readmission has not been well characterized. The aim of this study is to compare the risk of readmission after the two procedures in a large, nationally representative sample.
Methods Patients who underwent colorectal resection in 2011 were identified from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) database. LC and OC patients were compared for patient factors, complications, and readmission rates. A multivariable analysis controlling for significant factors was performed to evaluate factors associated with readmission.
Results Of 30,428 patients who underwent colorectal resection, 40.2% underwent LC. Length of stay (LOS) after LC was shorter than after OC (5.7 vs. 9.7 days, $p<0.001$). LC was associated with a significantly lower rate of surgical site infections (SSI), bleeding, reoperation, 30-day mortality, and complications. Risk of readmission was greater for patients undergoing proctectomy than colectomy (12.7 vs. 10.6 %, $p<0.001$), but was lower after laparoscopic than open for both procedures after controlling for confounding factors. Obesity, DM, operating time ≥180 min, steroid use, and ASA class 3–5 were found to be associated with readmission.
Conclusion Despite its technical complexity, LC can be performed without concerns for increased complications or readmission. The shorter length of stay and the lower risk of readmissions underline the true benefits of the laparoscopic approach for colorectal resection.

Keywords Readmission · NSQIP · Laparoscopy · Quality

Introduction

As measures for decreasing healthcare costs and increasing patient safety are implemented across all fields of medicine, various healthcare quality indicators have been developed and scrutinized. Postoperative complications and readmissions have become major quality indicators for health systems with one incident of readmission estimated to cost upwards of $9000 [1]. For institutions performing high-volume colorectal surgery, this can be problematic since these procedures have a relatively high risk of complications and readmissions [1–3]. Multiple clinical trials and single-institution studies have shown that laparoscopy reduces surgical site infection (SSI), narcotic requirement, ileus, and hospital length of stay (LOS) after colorectal resection [4–6]. These factors allow for quicker recovery postoperatively and thus earlier discharge compared to open surgery. However, the introduction of laparoscopic surgery and enhanced recovery pathways into the surgical community are postulated by some authors to have expedited discharge only to be offset by an increase in readmissions. This trend may even be contributing to an overall increase in hospital readmission rates—up to 20 %—over the past 2 decades [4, 7–9]. The aim of this study is to evaluate whether the benefits of laparoscopic colectomy extend to a

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large, nationally, representative sample and particularly, if any recovery benefits occur without a consequent increase in readmission rates.

Methods

Patients who underwent colorectal operations in 2011 were identified from the ACS NSQIP database. Characteristics of the database have been previously described [10]. Current procedural terminology (CPT) codes were used to stratify patients into the following two groups: open (OC) or laparoscopic (LC) colorectal resection. The Institutional Review Board at our institution reviewed and approved this study.

Patients were further grouped by gender and age. Other patient factors assessed were tobacco use, history of chronic obstructive pulmonary disease (COPD), hypertension requiring medication (HTN), previous myocardial infarction (MI), dialysis, and diabetes mellitus (DM). Data on American Society of Anesthesiologists (ASA) class, type of procedure (colectomy or proctectomy), body mass index (BMI), operative diagnosis, operative time, and surgical length of stay (LOS) were also evaluated. Ten generic diagnosis groups, based on International Statistical Classification of Diseases (ICD) codes, colorectal malignant neoplasm, colorectal benign neoplasm, inflammatory bowel disease (IBD)/ulcerative colitis (UC), acute colorectal disorder (clostridium difficile colitis, volvulus, obstruction, perforation, etc.), vascular insufficiency, other neoplastic disease (i.e., lymphoma), small bowel disease, fistula, miscellaneous (i.e., sepsis, injury to colon), and diverticular disease were created.

Complications and outcomes

Complications that were deemed "surgical" were surgical site infection (SSI), wound dehiscence, perioperative bleeding, and reoperation. "Medical" complications included pulmonary embolism (PE), deep venous thrombosis (DVT), urinary tract infection (UTI), pneumonia, failure to wean from the ventilator, reintubation, myocardial infarction (MI), stroke, and acute renal failure (ARF). Readmission and mortality within 30 days were the primary outcomes examined.

Statistics

Descriptive statistics such as frequency of comorbidities were computed for all categorical variables. Differences between groups were assessed using the chi-squared or Fisher exact tests. Quantitative variables were summarized using mean and standard deviation. The Student's *t*-test or the one-way ANOVA were used to compare groups. A p value of 0.05 or less was considered statistically significant. Relationships between variables and their association with readmission were assessed using multivariable logistic regression. SPSS 21 statistical software was used to perform the analyses.

Results

Patient characteristics

A total of 30,428 patients were identified after patients <18 years of age were excluded. Most patients (55.3 %) were younger than 65 years old, and there was a slight female preponderance (Table 1). The most common diagnoses were colorectal malignancy, present in 11,374 (37.4 %) patients, and diverticular disease, present in 5755 (18.9 %) patients. Most (59.8 %) patients underwent OC. Both groups had the same distribution of obese and nonobese patients. A greater proportion of patients in the OC group had comorbidity as evidenced by advanced ASA class, DM, COPD, previous MI, dialysis, and HTN, and were more likely to smoke, be on steroids, and to undergo emergency surgery. Surgical LOS was greater after OC than LC (9.7 vs 5.1 days, $p<0.001$).

Surgical complications

Surgical complications including superficial, deep, and organ space infections, overall SSI, wound dehiscence, perioperative bleeding, and reoperation were significantly lower after LC than OC (Table 2). Operative time (as determined by the mean operating time as well as proportions of patients undergoing operation lasting >180 min) was significantly greater after LC. Operating time was greater for laparoscopic proctectomy when compared to laparoscopic colectomy ($p<0.001$).

Medical complications

Medical complications including pneumonia, UTI, DVT, and PE were significantly less common after LC than OC (Table 3). LC patients also had a lower risk of pulmonary complications (reintubation and failure to wean from the ventilator), cardiovascular complications (MI and stroke), and acute renal failure than OC patients (Table 3).

Readmission and mortality

Thirty-day mortality was higher after OC than LC (Table 4). The overall readmission rate was 11.2 % ($n=3411$), and was higher after proctectomy than colectomy (12.7 vs. 10.6 %, $p<0.001$). The highest risk of readmission was in patients undergoing an open proctectomy, and the lowest in laparoscopic colectomy patents. Patients with medical (20 vs. 9.9 %, $p<0.001$), and surgical complications (22.1 vs. 7 %, $p<0.001$), respectively, were more likely to be readmitted than

Table 1 Demographics

Characteristic	Open (n=18,189)	Laparoscopic (n=12,239)	p value
Gender (female)	9567 (52.6 %)	6382 (52.1 %)	0.7
Age ≥65 years	8585 (47.2 %)	5016 (41 %)	<0.001
Body mass index ≥30 kg/m^2	5478 (30.9 %)	3700 (30.4 %)	0.3
ASA class 3–5	11,493 (63.2 %)	5067 (41.4 %)	<0.001
Diabetes mellitus	2914 (16.0 %)	1652 (13.5 %)	<0.001
Hypertension	9400 (51.7 %)	5769 (47.1 %)	<0.001
Chronic obstructive pulmonary disease	1410 (7.8 %)	499 (4.1 %)	<0.001
Previous myocardial infarction	97 (0.5 %)	24 (0.2 %)	<0.001
Dialysis	338 (1.9 %)	59 (0.5 %)	<0.001
Tobacco use	3647 (20.1 %)	1882 (15.4 %)	<0.001
Steroid use	1561 (8.6 %)	828 (6.8 %)	<0.001
Emergency surgery	4578 (25.2 %)	401 (3.3 %)	<0.001
Surgical LOS (days)[a]	9.7±8.9	5.7±5.1	<0.001

[a] Data presented as mean±SD

patients without the complications. LC was associated with a significantly lower rate of readmission than OC (9.0 vs. 13.2 %, p<0.001). Patients who were readmitted had a similar LOS as those who were not readmitted (8 vs. 7.8 days, p=0.18); however, for LC, readmitted patients had a longer initial LOS (6.3 vs. 5.6 days, p<0.001) than those who were not subsequently readmitted.

Multivariable regression analysis

Multivariable analysis performed to control for the effects of perioperative risk factors on readmission (Table 5) revealed that proctectomy, obesity (BMI≥30 kg/m^2), DM, operating time ≥180 min, tobacco use, steroid use, and ASA class 3–5 were associated with an increased risk of readmission while laparoscopic surgery was associated with a decreased risk of readmission. Surgery for a diagnosis of inflammatory bowel disease, acute colorectal conditions, and neoplastic disease was also associated with an increased risk of readmission.

Discussion

Surgical readmission is becoming a significant quality indicator in healthcare delivery, gaining interest among the media, insurance companies, and the government [2]. As hospitals continue to feel increasing pressure to decrease readmission rates, subspecialties such as colorectal with traditionally higher rates will come under scrutiny. Readmission rates in colorectal surgery have increased over the past 2 decades possibly due to a reduction in length of stay [3, 8]. While evidence from prospective studies suggests that laparoscopy is associated with lower complications and decreased length of stay when compared to open surgery data from such studies represent results obtained when the procedure is performed with strict inclusion criteria in select institutions and may not extrapolate to the wider surgical community. Further, whether the benefit of a shorter initial length of stay continues to be sustained over the long-term or instead leads to a rebound in readmission, particularly when the procedure is more

Table 2 Surgical complications

Complication	Open (n=18,189)	Laparoscopic (n=12,239)	p value
Superficial SSI	1522 (8.4 %)	629 (5.1 %)	<0.001
Deep SSI	372 (2.0 %)	119 (1 %)	<0.001
Organ space SSI	1106 (6.1 %)	399 (3.3 %)	<0.001
Overall SSI	2889 (15.9 %)	1121 (9.2 %)	<0.001
Dehiscence	412 (2.3 %)	82 (0.7 %)	<0.001
Bleeding	3903 (21.5 %)	757 (6.2 %)	<0.001
Operative time (min)[a]	172.4±104.2	177.6±88.6	<0.001
Operative time ≥180 min	6544 (36.0 %)	4807 (39.3 %)	<0.001
Return to OR	1345 (7.4 %)	582 (4.8 %)	<0.001

SSI surgical site infection

[a] Data presented as mean±SD

Table 3 Medical complications

Complication	Open (n=18,189)	Laparoscopic (n=12,239)	p value
Deep venous thrombosis	412 (2.3 %)	101 (0.8 %)	<0.001
Pulmonary embolism	202 (1.1 %)	57 (0.5 %)	<0.001
Urinary tract infection	863 (4.7 %)	299 (2.4 %)	<0.001
Pneumonia	892 (4.9 %)	171 (1.4 %)	<0.001
Reintubation	748 (4.1 %)	122 (1 %)	<0.001
Failure to wean	1436 (7.9 %)	118 (1 %)	<0.001
Myocardial infarction	197 (1.1 %)	60 (0.5 %)	<0.001
Stroke	97 (0.5 %)	23 (0.2 %)	<0.001
Acute renal failure	274 (1.5 %)	43 (0.4 %)	<0.001

universally adopted, has not been well characterized. In order to assess whether the initial benefits of laparoscopic colorectal surgery also extend out beyond the initial hospitalization, we evaluate the risk of readmission from a nationally representative sample. Our results suggest that LOS, medical complications, surgical complications, mortality, and risk of readmission are all reduced by laparoscopy.

When considering the entire spectrum of surgical care from the time of incision until the time of discharge, readmission is likely a reflection of a combination of factors including patient comorbidities, operative technique, intraoperative complications, immediate postoperative complications, and pain. Though OC and LC patients in our study were similar in terms of gender and BMI, they differed significantly in terms of preoperative comorbidities. In particular, advanced ASA class (classes 3–5), diabetes mellitus, tobacco use, and steroid use were significantly more common in OC than LC patients (Table 1). Other studies [2, 8, 11] confirm these findings and also our findings that these comorbidities are associated with higher rates of readmission after colorectal surgery. However, even when controlling for these preoperative comorbidities, LC was found to be associated with a significantly lower risk of readmission. A retrospective study by da Luz Moreira et al. demonstrated that even in ASA class 3–4 patients, laparoscopy has benefits over open surgery in terms of recovery time, hospital costs, and morbidity [12]. In terms of intraoperative factors, our multivariate analysis revealed several factors that were associated with readmission. In particular, proctectomy, operative time ≥180 min, and open surgery increased readmission risk. Increased operative time has been previously shown to be associated with increased readmission, particularly in patients undergoing proctectomy [13]. Higher surgical complexity can predict more surgical complications which are likely reflected in longer operative times and a higher likelihood of rehospitalization. Wick et al. also found proctectomy and length of stay >7 days to be associated with higher risk of readmission [1]. It is difficult to discern whether postoperative complications lead to greater length of stay or whether increasingly long hospitalizations put patients at risk for complications. DVT, PE, MI, stroke, and ARF can cause significant debility and have been shown to be associated with both extended hospital stays [14, 15] and an increased risk of readmission [2, 16–19]. Patients who developed both medical and surgical complications had a greater risk for readmission. The lower complication rates in LC demonstrated in this and other studies likely contribute to lower readmission rates despite the shorter LOS and increased operative time.

The findings of this study that suggest that LC is associated with a lower readmission rate are important. Traditionally any benefits after laparoscopic surgery over open surgery detected outside of a randomized controlled trial have been attributed to patient selection. However, with increasing expertise and with the technique and hence its widespread adoption, there are currently few contra-indications to the use of laparoscopy. While the use of a large nationwide sample suggests the generalizability of the findings of this study, the consideration of the various patient, disease, and operative factors that could serve as potential confounders in the analyses confirm the advantages of the benefits of LC both in terms of recovery after surgery as well as a reduced readmission rate instead of a paradoxical increase which may be a concern. The use of standardized definitions for the various variables including outcomes, follow-up of patients to 30 days after surgery, and

Table 4 Readmission and mortality

Characteristic	Open (n=18,189)	Laparoscopic (n=12,239)	p value
Readmission (colectomy)	1567 (13.2 %)	648 (9.0 %)	<0.001
Readmission (proctectomy)	701 (15.2 %)	495 (13.1 %)	0.008
Readmission (all)	2268 (12.5 %)	1143 (9.3 %)	<0.001
30-day mortality	1015 (5.6 %)	120 (1.0 %)	<0.001

Table 5 Multivariate analysis of factors associated with readmission

Variable	Readmission (%)	Odds ratio	Confidence interval	*p* value
Age <65	11.4 %	1.052	0.966–1.147	0.245
Gender (male)	11.1 %	0.962	0.894–1.036	0.31
Proctectomy	12.7 %	1.214	1.115–1.321	<0.001
Laparoscopy	9.3 %	0.76	0.7–0.826	<0.001
Body mass index ≥30 kg/m^2	12.4 %	1.149	1.059–1.247	0.001
Diabetes mellitus	13.4 %	1.16	1.047–1.287	0.005
Previous MI	14.9 %	1.17	0.87–1.56	0.302
Dialysis	14.6 %	1.11	0.66–1.85	0.697
Tobacco use	12.4 %	1.123	1.02–1.235	0.018
Chronic obstructive pulmonary disease	13.7 %	1.138	0.984–1.316	0.08
Hypertension	11.7 %	1.048	0.963–1.141	0.273
Steroid use	18.1 %	1.492	1.31–1.698	<0.001
ASA class 3–5	12.8 %	1.298	1.192–1.414	<0.001
Emergency surgery	11.2 %	0.918	0.814–1.036	0.167
Operative time ≥180 min	13.10 %	1.285	1.187–1.393	<0.001
Diagnoses				
Colorectal malignant neoplasm	10.8 %	1.11	0.804–1.008	0.07
Colorectal benign neoplasm	9.3 %	1.148	0.738–1.029	0.104
Inflammatory bowel disease	16.8 %	1.694	0.505–0.69	<0.001
Acute colorectal disorder	11.7 %	1.247	0.696–0.924	0.002
Vascular insufficiency	13.0 %	1.291	0.594–1.01	0.059
Other neoplastic disease	13.6 %	1.431	0.568–0.86	0.001
Small bowel disease	13.0 %	1.574	0.394–1.024	0.063
Fistula	13.5 %	1.204	0.613–1.126	0.233
Miscellaneous	10.8 %	1.057	0.795–1.124	0.527
Diverticular disease	9.4 %	REF	–	–

the inclusion of patients from all participating institutions around the country, which are strengths of the ACS sample also allowed an adequate evaluation of the risk of readmission of LC when compared to OC while controlling for other factors. Regardless of these strengths of this study, there are potential limitations. Considering the nature of the ACS sample, the problems with a retrospective study design are expected. Since procedures were only analyzed according to primary operative CPT codes, conversions from a laparoscopic to open technique were not accounted for separately. That there is also likely a selection bias in that patients undergoing LC were less ill and underwent emergency surgery at a lower rate than OC patients is another potential drawback. However, we compensated for this by looking at readmission risk factors on multivariable analysis and still found laparoscopy to be associated with lower readmission rates.

The findings of this study support the recovery benefits of laparoscopic over open colorectal resection. Despite its technical complexity and a consequently longer operating time, the minimally invasive approach is associated with a lower risk of complications, shorter length of hospital stay, and reduced readmission. These findings, detected even within a nationwide sample of patients, suggest the generalizability of the advantages of the laparoscopic approach to colorectal patients undergoing surgery even outside of clinical trials.

Authors' contributions Iyare O. Esemuede and Ravi P. Kiran made substantial contributions to the conception and design of the project as well as acquisition, analysis, and interpretation of data. Iyare O. Esemuede, Alodia Gabre-Kidan, Ravi P. Kiran, and Dennis L. Fowler made significant contributions to drafting and revising the article. Final approval of the version to be published was done by all four authors.

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