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Does Conversion in Laparoscopic Colectomy Portend an Inferior Oncologic Outcome? Results from 104,400 Patients

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Abstract

Background—Limited data exist regarding the effect of conversion from laparoscopic to open colectomy on perioperative and oncologic outcomes in colon cancer.

Study Design—The National Cancer Data Base was used to identify patients who underwent colectomy for non-metastatic colon cancer (2010–2012). Patients were stratified into three groups: laparoscopic/robotic-assisted colectomy (MIC), converted colectomy (CC), and open colectomy (OC). Multivariable modeling was applied to compare outcomes from CC and MIC to OC while adjusting for patient, clinical, and tumor characteristics.

Results—Of 104,400 patients, 40,328 (38.6 %) underwent MIC, 57,928 (55.5 %) OC, and 6144 (5.9 %) CC. After adjustment, the rate of positive surgical margins was not significantly different between CC and OC ($p = 0.44$). However, with adjustment, CC versus OC was associated with shorter hospital length of stay (4 % decrease, 95 % CI 2–5 %, $p < 0.0001$) and lower odds of 30-day mortality (OR 0.77, 95 % CI 0.64–0.94, $p = 0.0112$). Adjusted overall survival was similar between CC and OC ($p = 0.34$).

Conclusions—Conversion from laparoscopic to open colectomy was not associated with compromised oncologic outcomes, while maintaining improved short-term outcomes despite being attempted in only 45 % of patients. This data suggests that utilization of laparoscopic colectomy should be attempted for patients with colon cancer.

Keywords

Minimally invasive surgery; Colectomy; Colon cancer

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Compliance with Ethical Standards

Conflict of Interest Data will be presented at the 11th Academic Surgical Congress in Jacksonville, FL, on February 2–4, 2016. The data used in the study are derived from a de-identified National Cancer Data Base (NCDB) file. The American College of Surgeons and the Commission on Cancer have not verified and are not responsible for the analytic or statistical methodology employed or the conclusions drawn from these data by the investigator.

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Introduction

Laparoscopic colectomy continues to gain popularity as the approach of choice for the surgical management of colon cancer.[1] Multiple randomized controlled trials and observational studies have demonstrated either equivalence or superiority of laparoscopic colectomy on short-term outcomes and its equivalent oncologic outlook.[2–4] Despite this information, a relatively high rate of conversion from laparoscopic to open colectomy exists, and some have suggested that these patients may have poorer outcomes. Indications for conversion during laparoscopic colectomy include inability to perform en bloc resection or adequate lymphadenectomy.[5–9]

Although a few studies have focused on short-term outcomes associated with conversion from laparoscopic to open colectomy, little is known about the effect of conversion on patient short- and long-term oncologic outcomes at the population level. Previous literature suggests that conversion in colectomy is associated with increased postoperative morbidity and mortality.[5,7–9] In particular, the need for conversion is often associated with intraoperative bleeding, suboptimal visualization of the surgical field, and/or unsuccessful attempts of complete resection of the tumor laparoscopically. These events have the potential for compromising the adequacy of the oncologic resection of the tumors. Thus, it is unclear if conversion is associated with a negative impact on oncologic outcomes. The purpose of this study was to analyze short-term oncologic outcomes and survival between patients who experienced conversion from laparoscopic to open colectomy with patients who underwent open colectomy on a national level.

Materials and Methods

The Duke University Institutional Review Board approved this retrospective review of the National Cancer Data Base (NCDB). The NCDB, established in 1989, is a nationwide, facility-based, comprehensive clinical surveillance resource oncology data set that currently captures 70 % of all newly diagnosed malignancies in the USA annually. The NCDB is jointly administered by the American College of Surgeons and the American Cancer Society and collects data from greater than 1500 cancer institutions. The database currently contains data from >30 million patient records. The American College of Surgeons has executed a Business Associate Agreement that includes a data use agreement with each of its Commission on Cancer-accredited hospitals.

We used the NCDB Participant User File to identify all patients with non-metastatic colon cancer who underwent segmental colectomy between 2010 and 2012. Variables such as patient age at diagnosis, race, sex, annual income, insurance status, Charlson-Deyo score, and year of diagnosis were obtained from the database. Annual income data were determined by the NCDB by linking each patient’s zip code to the year 2000 United States Census data. Data on extent of surgery, status of the surgical margins, tumor size, histology, tumor grade, and patient pathologic stage were extracted from the database.

Patients with stage I–III colon adenocarcinoma who underwent isolated colon resection were included in the study. Patients with non-malignant pathology or missing data on surgical

approach were excluded. The remaining patients were categorized into three groups based on surgical approach: laparoscopic and robotic-assisted colectomy (MIC), open colectomy (OC), and MIC converted to open colectomy (CC).

Statistical Analysis

The primary endpoints of our study were completeness of surgical resection and overall survival. Secondary endpoints included lymph nodes examined, hospital length of stay, and 30-day mortality.

Baseline characteristics between the three groups were compared using the Kruskal-Wallis test for continuous variables and chi-squared tests for categorical variables. Multivariable logistic regression modeling was used to examine binary outcomes. Survival analysis was performed using a multivariable Cox proportional hazards regression model. In the survival analysis, we excluded patients who died within 30 days of their operation. In all multivariable models, we adjusted for patient age, gender, race, insurance status, treatment facility type (community, comprehensive community, or academic), Charlson-Deyo comorbidity score, American Joint Committee on Cancer tumor pathologic stage, and extent of surgery. All p values reported are two-sided with the significance level set a priori at 0.05. All analyses were performed using SAS version 9.4 (SAS, Cary, NC, USA).

Results

Baseline Characteristics

A total of 104,400 met inclusion criteria. Of these, 40,328 (38.6 %) patients underwent MIC, 57,928 (55.5 %) patients underwent OC, and 6144 (5.9 %) patients underwent CC. The conversion rate in the cohort was 13.2 %. Baseline characteristics for the three groups are listed in Table 1. Differences existed between the three groups but were of little clinical significance. Compared to MIC, patients in the CC group were more often male (54 versus 49 %), black (13 versus 10 %), from a less affluent area (40 versus 37 %), insured by Medicare or Medicaid (63 versus 61 %), from the Midwest (28 versus 25 %), with stage II–III disease (71 versus 64 %), and with high-grade tumors (18 versus 17 %) (all $p < 0.01$). However, patients in the MIC group were more often without comorbidities (67 versus 64 %), from a non-rural location (96 versus 65 %), from the Northeast (23 versus 21 %), and treated at an academic comprehensive cancer program (27 versus 25 %).

Although utilization of minimally invasive approaches increased from 39.3 % (13,606 cases) in 2010 to 49.6 % (17,163 cases) in 2012, the conversion rates slightly decreased throughout the study period: 14.0 % in 2010, 13.5 % in 2011, and 12.3 % in 2012 (Table 2).

Oncologic and Short-Term Outcomes

In the unadjusted analysis, the numbers of lymph nodes removed were not clinically different between CC and OC: 18 versus 17, respectively. Compared to MIC, the rate of positive surgical margins was higher in the CC group (5.2 versus 2.7 %, $p = 0.001$), but similar to the OC group (5.2 %). Hospital length of stay was longer in the CC versus MIC group (median 4 versus 3 days), but it was shorter for those in the open group (4 versus 5

days) (p <0.001). Rates of unplanned 30-day readmission were higher in the CC versus MIC (7.5 versus 5.0 %), but comparable for those in the open group (7.5 versus 5.9 %). Mortality at 30 days after surgery was slightly higher in the OC group (2.8 %) compared to 1.9 % in the CC group and 1.0 % in the MIC group (p <0.001) (Table 3).

The results of the adjusted outcomes are summarized in Table 4. After adjustment for patient, clinical, and treatment characteristics, CC versus OC was associated with a similar rate of positive surgical margins (odds ratio (OR) 1.05, 95 % confidence interval (CI) 0.93–1.19, p = 0.445), a slightly higher number of lymph nodes retrieved (2 % increase (0.5 lymph node), 95 % CI 1–4 %, p = 0.001), and a shorter hospital length of stay (4 % decrease, 95 % CI 2–5 %, p < 0.001). With adjustment, CC was associated with a significantly decreased odds of 30-day mortality when compared to OC (OR 0.77, 95 % CI 0.64–0.94, p = 0.011).

Median follow-up time was 24 months (range 1–51 months). In unadjusted analysis, 2-year overall survival was comparable between patients in the CC versus the OC groups (85 versus 83 %). After adjustment for patient age, gender, race, insurance status, comorbidities, pathologic stage, tumor grade, extent of surgery, surgical margins, adjuvant chemotherapy, and hospital type, CC was associated with comparable overall survival when compared to OC (hazard ratio (HR) 0.96, 95 % CI 0.88–1.05, p = 0.343).

Discussion

In this large nationally representative study of patients undergoing colectomy for non-metastatic colon cancer, we demonstrated that successfully completed laparoscopic colectomy versus open colectomy is associated with improved short-term outcomes and equivalent oncologic results. Conversion from planned laparoscopic colectomy to open colectomy is still associated with favorable surgical short-term outcomes such as shorter hospitalization period and improved 30-day mortality, compared to standard open colectomy. Completeness of oncologic resection and mid-term survival were not compromised in patients experiencing conversions. Despite these results, only 45 % of the patients underwent an attempted laparoscopic colectomy in the management of their colon adenocarcinoma.

While there have been numerous studies that examined the impact of conversion from laparoscopic colectomy to open colectomy on surgical and oncologic outcomes, limited data exist with regard to the effect of conversion in comparison to open surgery. To adequately inform on the oncologic safety of laparoscopic colectomy, one must know the effect of conversion in comparison to open cases, as some may suggest that these cases should have been started via open approach. Li et al. published a retrospective multi-institution analysis in China with 395 patients who underwent colectomy for non-metastatic colon adenocarcinoma. The authors found a similar disease-free survival and overall survival between their laparoscopic, converted, and open colectomy cohorts.[10] Given the small sample size in their analysis, they were likely underpowered to show any difference among their three groups. Additionally, this study included patients from two high-volume institutions in China, which potentially limits the generalizability of these results to the US

population. Our study improves on these limitations by using a national database from the USA that includes a greater number of patients represented from all over the country.

Mosoomi et al. published a retrospective review analysis which included 207,311 patients from the National Inpatient Sample (NIS) who underwent laparoscopic, converted, and open resection of their colon and rectum for all indications. Endpoints included in-hospital mortality, complication rate (urinary tract infection, pneumonia, respiratory failure, acute kidney injury, myocardial infarction, deep venous thrombosis, pulmonary thromboembolism, ileus, wound infection, wound dehiscence, abdominal abscess, and bowel obstruction), length of stay, and total hospital charges. The authors found a lower in-hospital mortality for converted patients and a similar overall complication rate when compared to open patients.[6] Though the length of stay was similar between the open and converted groups, the mean total hospital charge for the open cohort was $8000 greater than the conversion cohort. While informative, this study did not account for tumor characteristics such as tumor histology and stage when examining the effect of conversion on patients' outcomes. Furthermore, as a limitation of the NIS data sets, the authors did not provide data on oncologic outcomes such as the number of lymph nodes removed during surgery, completeness of tumor resection, or survival for those cases that involved cancer. Using the NCDB, this study examined the effect of conversion on short-term surgical outcomes and oncologic endpoints, while adjusting for tumor characteristics. After multivariable adjustment, we demonstrated that conversion during colectomy for colon adenocarcinoma was associated with improved short-term outcomes compared to open surgery, with shorter hospitalization and reduced 30-day mortality similar to the findings reported by Mosoomi et al. In addition, our analysis demonstrated superior lymph node retrieval and similar overall survival when converted colectomy patients are compared to open patients.

Multiple studies, including several randomized control trials, have shown no difference in overall survival between laparoscopic colectomy and open colectomy and demonstrated the equivalence of the two approaches.[2,4,11–16] However, most of these analyses were based on the intention-to-treat principle and did not specifically analyze the effect of conversion on oncologic outcomes. Thus, these studies did not adequately address the question of whether conversion is safe. Multiple other studies have analyzed outcomes between those patients who underwent completed laparoscopic colectomy and those patients who underwent conversion after initial laparoscopic attempt. Similar to our findings, these studies have demonstrated the superiority of completed laparoscopic colectomy to converted colectomy.

Scheidbach et al. published results from a retrospective multicenter study of 1409 patients, in which they compared converted patients to laparoscopic or laparoscopic-assisted patients. They reported statistically higher rates of anastomotic leak, reoperation, and overall 5-year mortality in patients who experienced conversion but similar disease-free survival between the groups.[8] White et al. reported a retrospective single-institution cohort study of 175 patients who underwent a laparoscopic colectomy for stage I–III colon cancer. Among 175 patients, 25 (14 %) were converted to open surgery. Compared to completed laparoscopic cases, patients who experienced conversion were more likely to have major postoperative complications and prolonged hospitalization. With a mean follow-up time of 33 months, disease-free survival was worse for converted patients when compared to complete

laparoscopic patients.[9] Similarly, Moloo et al. reported a retrospective single-institution study in which they analyzed data from 377 patients with colon cancer who underwent colectomy, and compared those who were converted with patients who underwent laparoscopic colectomy. Their analysis showed that patients with conversion had a statistically compromised 2- and 5-year survival when compared with laparoscopic patients.[7] Chan et al. published an analysis of 470 patients who underwent laparoscopic colectomy at a single institution. In their cohort, 41 patients were converted to open colectomy. In their analysis comparing the converted patients to those who underwent laparoscopic colectomy, disease-free survival and local recurrence were statistically worse in the conversion cohort compared with the laparoscopic cohort.[5]

Our study differs from these analyses though by comparing patients who underwent a converted colectomy to patients who underwent an open colectomy. When attempting to determine the harm associated with conversion, a comparison to open colectomy is the most appropriate. Additionally, compared to the studies above, our analysis is more generalizable to the population and avoids the selection bias associated with single- or multi-institutional studies. Finally, these studies were all performed at least 4 years ago. As our study highlight, the adoption of laparoscopic colectomy has continued to increase over time, perhaps making surgeons more experienced than they were when these studies were published.

Our study has several limitations. First, our analysis was retrospective in nature, which limits it to possible selection bias. However, we adjusted for known clinical, socioeconomic, hospital, and tumor characteristics to limit this effect. Second, we could not asses for important variables such as BMI and number of previous operations which are known to affect conversion rate. Though we adjusted for known interactions and confounders, the presence of unknown interactions and confounders is possible. Third, the median survival of the overall cohort was only 24 months which may not be long enough to assess a difference in overall survival between the conversion group and the open group. Additionally, we report overall survival as opposed to cancer-free survival which is a limitation of the NCDB. Despite these limitations, our study is the largest analysis to examine the effect of conversion from laparoscopic to open colectomy on surgical and oncologic outcomes.

Conclusion

In this nationally representative study, patients with non-metastatic colon cancer who underwent laparoscopic or robotic-assisted attempts at colon resection and were converted to open colectomy had a similar incidence of completeness of tumor resection and survival compared with standard open colectomy, with the benefit of shorter hospital length of stay and improved 30-day mortality. Despite these results, only 43 % of colon cancer patients in the USA are considered for laparoscopic colectomy. This analysis demonstrates that laparoscopic colectomy should be considered for colon cancer patients who do not have contraindications to laparoscopy, and that conversion can be done safely when necessary, without compromising oncologic outcomes.

Abbreviations

AJCC	American Joint Committee on Cancer
CC	Conversion of laparoscopic or robotic-assisted colectomy to open colectomy
CI	Confidence interval
HR	Hazard ratio
MIC	Laparoscopic or robotic-assisted colectomy
NCDB	National Cancer Data Base
NIS	National Impatient Sample
OC	Open colectomy
OR	Odds ratio

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Table 1

Characteristics of patients with non-metastatic colon cancer who underwent colon resection from 2010 to 2012 in the National Cancer Data Base

	MIC (*N* = 40,328)	CC (*N* = 6144)	OC (*N* = 57,928)	*p* value
Age (years)	59/70/79	59/69/79	61/71/80	<0.001
Male	19,738 (48.9 %)	3308 (53.8 %)	27,756 (47.9 %)	<0.001
Race				<0.001
Asian	1243 (3.1 %)	181 (3.0 %)	1529 (2.6 %)	
Black	4210 (10.4 %)	804 (13.1 %)	7466 (12.9 %)	
White	34,143 (84.7 %)	5041 (82.1 %)	47,988 (82.8 %)	
Other	732 (1.8 %)	118 (1.9 %)	945 (1.6 %)	
Annual income < $48,000	14,772 (36.6 %)	2439 (39.7 %)	25,765 (44.5 %)	<0.001
Insurance status				<0.001
Medicare/Medicaid	24,404 (60.5 %)	3842 (62.5 %)	37,967 (65.5 %)	
Private	14,367 (35.6 %)	1986 (32.3 %)	16,422 (28.4 %)	
Other	340 (0.8 %)	55 (0.9 %)	439 (0.8 %)	
None	852 (2.1 %)	188 (3.1 %)	2170 (3.8 %)	
Charlson-Deyo Comorbidity Index				<0.001
0	27,199 (67.4 %)	3917 (63.8 %)	38,419 (66.3 %)	
1	9544 (23.7 %)	1641 (26.7 %)	13,778 (23.8 %)	
≥2	3585 (8.9 %)	586 (9.5 %)	5731 (9.9 %)	
Rural–urban commuting area				<0.001
Urban	38,658 (95.9 %)	5851 (95.2 %)	54,944 (94.9 %)	
Rural	690 (1.7 %)	122 (2.0 %)	1281 (2.2 %)	
Hospital location				<0.001
Northeast	9073 (22.5 %)	1283 (20.9 %)	10,686 (18.5 %)	
Midwest	9980 (24.8 %)	1695 (27.6 %)	15,926 (27.5 %)	
South	14,691 (36.4 %)	2222 (36.2 %)	22,565 (39.0 %)	
West	6584 (16.3 %)	944 (15.4 %)	8751 (15.1 %)	
Facility type				<0.001
Community	4525 (11.2 %)	853 (13.9 %)	10,212 (17.6 %)	
Comprehensive community	24,706 (61.3 %)	3728 (60.7 %)	33,936 (58.6 %)	
Academic comprehensive	11,053 (27.4 %)	1558 (25.4 %)	13,694 (23.6 %)	
Year of diagnosis				<0.001
2010	11,699 (29.0 %)	1907 (31.0 %)	21,016 (36.3 %)	
2011	13,578 (33. 7 %)	2125 (34.6 %)	19,469 (33.6 %)	
2012	15,051 (37.3 %)	2112 (34.4 %)	17,443 (30.1 %)	
Tumor size (cm)	2.5/3.7/5.2	2.6/4.0/5.8	3.0/4.2/6.0	<0.001
Clinical stage				<0.001
Stage I	14,634 (36.3 %)	1793 (29.2 %)	15,081 (26.0 %)	
Stage II	12,964 (32.2 %)	2185 (35.6 %)	21,621 (37.3 %)	
Stage III	12,730 (31.6 %)	2166 (35.3 %)	21,226 (36.6 %)	

	MIC (*N* = 40,328)	CC (*N* = 6144)	OC (*N* = 57,928)	*p* value
High-grade dysplasia	6687 (16.6 %)	1119 (18.2 %)	10,941 (18.9 %)	<0.001
Extent of surgery				<0.001
Segmental colectomy	39,489 (97.9 %)	5976 (97.3 %)	55,853 (96.4 %)	
Total abdominal colectomy	678 (1.7 %)	133 (2.2 %)	1739 (3.0 %)	
Total proctocolectomy	161 (0.4 %)	35 (0.6 %)	336 (0.58 %)	

Data are represented as the number of patients (percent) for categorical variables and Q1/median/Q3 for continuous variables unless otherwise specified

MIC laparoscopic or robotic-assisted colectomy, *CC* laparoscopic or robotic colectomy converted to open colectomy, *OC* open colectomy

Table 2

Minimally invasive colectomy utilization and conversion rate from 2010 to 2012 in the National Cancer Data Base

	MIC utilization (%)	Conversion rate (%)
2010	39.3	14.0
2011	44.6	13.5
2012	49.6	12.3

MIC all attempted laparoscopic or robotic-assisted colectomy operations

Table 3

Unadjusted outcomes of patients with non-metastatic colon cancer who underwent colon resection from 2010 to 2012 in the National Cancer Data Base

	MIC (*N* = 40,328)	CC (*N* = 6144)	OC (*N* = 57,928)	*p* value
Lymph nodes extracted	13/18/24	13/18/24	13/17/23	<0.001
Positive margin	1075 (2.7 %)	319 (5.2 %)	3014 (5.2 %)	<0.001
Hospital length of stay	3/5/6	4/6/8	5/6/9	<0.001
30-day readmission	2005 (5.0 %)	460 (7.5 %)	3412 (5.9 %)	<0.001
30-day mortality	419 (1.0 %)	115 (1.9 %)	1637 (2.8 %)	<0.001

Data are represented as the number of patients (percent) for categorical variables and Q1/median/Q3 for continuous variables unless otherwise specified

MIC laparoscopic or robotic-assisted colectomy, *CC* laparoscopic or robotic colectomy converted to open colectomy, *OC* open colectomy

Table 4

Adjusted outcomes of patients by procedure type compared to open colectomy

Outcomes (compared to OC)	CC	*p* value	MIC	*p* value
Positive resection margins	1.05 (0.93–1.19)	0.445	0.58 (0.54–0.63)	<0.001
Lymph nodes harvested (percent increase)	2 % (1–4 %)	0.001	3 % (3–4 %)	<0.001
Hospital length of stay (percent decrease)	4 % (2–5 %)	<0.001	23 % (22–24 %)	<0.001
30-day mortality	0.77 (0.64–0.94)	0.011	0.47 (0.42–0.52)	<0.001
Adjusted survival (hazard ratio)	0.96 (0.88–1.05)	0.343	0.69 (0.66–0.73)	<0.001

Data are represented as the number of odds ratio (confidence interval) unless otherwise specified

MIC laparoscopic or robotic-assisted colectomy, *CC* laparoscopic or robotic colectomy converted to open colectomy, *OC* open colectomy