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Short-term outcomes of laparoscopic approach to colonic obstruction for colon cancer

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Abstract

Background We speculated that a laparoscopic approach to emergent/urgent partial colectomy for colonic obstruction would be associated with less morbidity and shorter length of stay with similar mortality to open colectomy. We compared the outcomes of laparoscopic and open approaches to emergent/urgent partial colectomy for colonic obstruction from colonic cancer using data from the National Surgical Quality Improvement Program (NSQIP) database for the period of 2012–2017. Methods Multivariate analysis compared NSQIP data points following laparoscopic, laparoscopic converted to open, and open colectomy for emergent/urgent colectomy for colonic obstruction from colon cancer from 2012 to 2017.

Results A total of 1293 patients who underwent emergent colectomy for colon obstruction from colon cancer during 2012– 2017 were identified within the NSQIP database. Laparoscopic approach was used for colonic obstruction in 19.3% of operations with a conversion rate of 28.5%. A laparoscopic approach to obstructing colonic cancers was associated with lower morbidity (50% vs. 61.8%, AOR: 0.67, $P = 0.01$) and shorter hospitalization length (10 days vs. 13 days, mean difference: 3 days, $P < 0.01$) compared with an open approach. However, the mean operation duration was longer in laparoscopic operations than open operations (159 min vs. 137 min, $P < 0.01$).

Conclusion A laparoscopic approach to malignant colonic obstruction is associated with decreased morbidity. This suggests that efforts should be directed towards increasing the utilization of laparoscopic approaches for the surgical treatment of colonic obstruction.

Minimally invasive colectomy is the standard of care for the elective surgical management of colonic diseases [1, 2]. Multiple advantages of minimally invasive colectomy such as lower morbidity, faster recovery, and better cosmetic outcomes compared to conventional open surgery in elective settings justify the implementation of laparoscopic surgery into routine practice [1, 3]. Recent published data reveal that by 2012 a majority of patients undergoing an elective colectomy for diverticulitis and cancer received a laparoscopic operation

in the USA [1]. However, safety, benefits, feasibility, and utilization of the laparoscopic approach in emergent colorectal resections are unclear.

It is reported that 13–16% of patients with colorectal cancer present with colonic obstruction [4–6]. Such patients frequently require urgent/emergent operation and they have a significant mortality and morbidity [4–6]. It is estimated that 25% of postoperative deaths after colorectal cancer operations occur in patients presenting with obstruction [6]. Decreasing the mortality and morbidity of such patients is important. Patients with colonic obstruction may benefit from a minimally invasive colectomy approach. Although the feasibility of the laparoscopic approach has been reported in a few studies by experienced surgeons, overall such conclusions need to be confirmed by a large randomized trial or a large national study with careful adjustment for perioperative factors [2, 7, 8]. Using a nationwide database, this study aims to investigate outcomes of patients with colonic obstruction for colon cancer who underwent colon resection by laparoscopic compared to open surgical approach.

Methods

A multicenter retrospective study was performed using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to investigate outcomes of emergent colon resection for obstructing colon cancer by surgical approach. The study hypothesis was that laparoscopic approaches to colonic obstruction are associated with reduced morbidity & mortality of patients. We queried patients who underwent colectomy whose data were submitted to the ACS-NSQIP during the study period of 1/1/2012 to 12/31/2017 using the Participant Use Data Files (PUF) and the targeted colectomy files. The NSQIP database is a large national database extracted from medical records by trained surgical clinical reviewers in more than 600 participating hospitals of varying sizes and academic affiliations to NSQIP [9]. The NSQIP data include more than 150 demographics, preoperative, intraoperative, and 30-day postoperative variables [9]. This study uses de-identified data from ACS-NSQIP database that is not considered Human Subjects Research and was exempt from IRB approval.

In this study, we query a subset of adult patients (age 18 years old and more) who underwent emergent colectomy for obstructing colon cancer using existing variables of “primary indication for surgery” and “emergent vs. elective surgery” from NSQIP targeted file for colectomy during 2012–2016. The obstruction site in the colon was defined according to the patient diagnosis such as cecal cancer, ascending colon cancer, hepatic flexure cancer, etc. Type of the procedure was defined based on the current procedural terminology (CPT) codes of 44,140–44,147 and 44,204–44,208 for open and laparoscopic partial colectomy, respectively. Patients without information regarding the operation type, the resection type, and type of the surgery (emergent), and patients who did not have colon cancer in final pathology were excluded from the study. We excluded patients who underwent robotic or hybrid procedures from the study due to the low number of cases. Also, patients who had clean wound classification were excluded from the study. All variables considered in this study were defined per the NSQIP User Guide definition, which is available online [9]. We excluded the NSQIP variable of “margin status” from study due to missing data (80%).

Investigated variables included demographic data (age, sex, and race), patient comorbidities (hypertension, coagulopathy, diabetes mellitus, etc.), operative factors (operation length, surgical approach, stoma creation, etc.), and outcomes (postoperative complications, mortality, hospitalization length, etc.). We divided patients based on the surgical approach (open vs. laparoscopic). Laparoscopic patients converted to open surgery were analyzed in overall laparoscopic group. The primary endpoint is the postoperative complication rates of patients by surgical approach. Overall morbidity is defined as presence of one of the postoperative complications of intra-abdominal infection, sepsis, septic shock, ventilator dependency, cardiac arrest, acute renal failure, hemorrhagic complication that needs transfusion, pulmonary embolism, myocardial infarction, pneumonia, central vascular accident, superficial surgical site infection, deep surgical site infection, unplanned reoperation, deep venous thromboembolism, urinary tract infection, progressive renal insufficiency, unplanned intubation, anastomosis leakage, prolonged ileus, and wound disruption. Also, severe morbidity is defined as presence of one of the complications of intra-abdominal infection, septic shock, ventilator dependency, cardiac arrest, acute renal failure, pulmonary embolism, myocardial infarction, pneumonia, unplanned reoperation, unplanned intubation, and anastomosis leakage.

Statistical analysis

Descriptive statistics were used to characterize the patients by surgical approach. The one-way analysis of variance was used to assess the difference in mean for continuous variables. The Pearson's Chi-squared test was used to determine the difference in proportions for dichotomous and categorical variables among groups. Univariate analysis was performed to compare patients in different groups for each variable. Variables with and unadjusted P value < 0.05 from univariate analyses were used to build a multivariable logistic regression model to identify independent risk factors for primary adverse outcomes. Covariates were age, sex, race, available comorbidities in NSQIP database, wound class, tumor pathological stage, obstruction site, ASA class, operation length, partial or complete dependency before surgery, preoperative leukocytosis, preoperative chemotherapy, smoking, and hypoalbuminemia. P values < 0.05 were considered significant. Adjusted Odd Ratio (AOR) was calculated for all variables included in multivariate analysis. All statistical tests were performed using the Statistical Package for Social Sciences (SPSS) software, version 22 (SPSS Inc., Chicago, IL).

Results

A total of 1293 patients who underwent emergent colectomy for obstructing colon cancer were identified during 1/1/2012–12/31/2017 within the database. Most patients were Caucasian (79.2%) and male (50.1%). The most prevalent comorbidities included hypertension (48.6%) and diabetes (15.8%). Overall, 17% of patients had ascending colon cancer, 19.2% cecal cancer, 5.1% hepatic flexure, 13% transverse colon cancer, 5.1% splenic flexure cancer, 9.1% descending colon cancer, 24.1% sigmoid cancer, and 7.3% rectosigmoid junction cancer. Laparoscopic approach was used for colonic obstruction in 19.3% of operations. The descriptive statistics and patient demographics by surgical approach are summarized in Table 1.

Table 1 Demographics and clinical characteristics of patient population of the study

Variables	Patients with planned open surgery *N* (%) total = 1044	Patients with laparoscopic approach *N* (%) total = 249	*P* value
Age			
Mean (± standard deviation)	69 (± 14) years	68 (± 16) years	0.46
Median	71 years	70 years	–
Sex			
Female	514 (49.2%)	132 (53%)	0.28
Race			
White	558 (78.8%)	137 (81.1%)	0.51
Black or African American	103 (14.5%)	15 (8.9%)	0.05
Asian	40 (5.6%)	13 (7.7%)	0.31
Other	7 (1%)	4 (2.4%)	0.14
Comorbidity			
Diabetes mellitus	164 (15.7%)	40 (16.1%)	0.89
Weight loss	123 (11.8%)	26 (10.4%)	0.55
Congestive heart failure	20 (1.9%)	2 (0.8%)	0.22
Chronic steroid use	34 (3.3%)	2 (0.8%)	0.03
Chronic obstructive pulmonary disease	73 (7%)	8 (3.2%)	0.02
Moderate to severe dyspnea	84 (8%)	13 (5.2%)	0.12
End stage renal disease on dialysis	6 (0.6%)	2 (0.8%)	0.67
Ascites	64 (6.1%)	10 (4%)	0.19
Disseminated cancer	318 (30.5%)	70 (28.1%)	0.46
Hypertension	507 (48.6%)	122 (49%)	0.90
Malignant obstruction site			
Cecal cancer	76 (18.4%)	21 (22.3%)	0.38
Ascending colon cancer	68 (16.5%)	18 (19.1%)	0.53
Hepatic flexure cancer	18 (4.4%)	8 (8.5%)	0.10
Transverse colon cancer	53 (12.9%)	13 (13.8%)	0.80
Splenic flexure cancer	21 (5.1%)	5 (5.3%)	0.93
Descending colon cancer	39 (9.5%)	7 (7.4%)	0.53
Sigmoid cancer	106 (25.7%)	16 (17%)	0.07
Rectosigmoid junction	31 (7.5%)	6 (6.4%)	0.70
Wound class			
Clean/contaminated	661 (61.3%)	184 (73.9%)	< 0.01
Contaminated	227 (21.7%)	44 (17.7%)	0.15
Dirty	156 (14.9%)	21 (8.4%)	< 0.01
American Society of Anesthesiologists (ASA) Score			
I	23 (2.2%)	5 (0.2%)	0.84
II	243 (23.3%)	77 (30.9%)	0.01
III	548 (52.6%)	132 (53%)	0.90
IV	228 (21.9%)	35 (14.1%)	< 0.01
Pathological stage			
I	10 (1.4%)	3 (1.8%)	0.74
II	194 (27.3%)	43 (26.2%)	0.62
III	274 (38.5%)	74 (45.1%)	0.20
IV	233 (32.8%)	44 (26.8%)	0.14
Dependency before surgery			
Independent	966 (93.3%)	234 (94.4%)	0.83
Partial dependency	55 (5.3%)	14 (5.6%)	0.83
Complete dependency	14 (1.4%)	0	0.06
Other factors			

Operation length [mean ± standard deviation]	137 (± 66) min	159 (± 70) min	< 0.01
Preoperative leukocytosis	424 (40.8%)	74 (30.1%)	< 0.01
Preoperative chemotherapy	65 (6.3%)	9 (3.6%)	0.10
Smoking	193 (18.5%)	28 (11.2%)	< 0.01
Creation of a stoma	447 (42.8%)	50 (20.1%)	< 0.01
Severe hypoalbuminemia[a]	208 (24%)	42 (21.6%)	0.48

[a]Serum albumin level less than 3 g/dL

Overall, 249 (19.3%) of the operations were done laparoscopic. Conversion to open happened in 28.5% of the cases. Mean operation duration was longer in laparoscopic operations compared to open operations (159 min vs. 137 min, $P < 0.01$). Associations between postoperative morbidity and perioperative factors are reported in Table 2. Patients who developed morbidity had a higher rate of chronic obstructive pulmonary disease (COPD), hypertension, and severe hypoalbuminemia. On multivariate analysis factors of operation time, severe hypoalbuminemia, and surgical approach were significantly associated with morbidity of the patients (Table 3). Also, patients with dirty wound classification had significantly higher morbidity compared to the patients who had a clean/contaminated wound (Table 3).

Table 2 Univariate analysis of factors associated with morbidity of the patients

Variables	Patients with postoperative morbidity *N* (%) total = 728	Patients without postoperative morbidity *N* (%) total = 562	*P* value
Age			
Mean (± standard deviation)	69 (± 14) years	69 (± 15) years	0.45
Median	71 years	72 years	–
Sex			
Female	321 (44.1%)	322 (57.3%)	< 0.01
Race			
White	380 (76.8%)	312 (82.3%)	0.04
Black or African American	81 (16.4%)	37 (9.8%)	< 0.01
Asian	29 (5.9%)	24 (6.3%)	0.77
Other	5 (1%)	6 (1.6%)	0.45
Comorbidity			
Diabetes mellitus	123 (16.9%)	81 (14.4%)	0.22
Weight loss	93 (12.8%)	56 (10%)	0.11
Congestive heart failure	14 (1.9%)	8 (1.4%)	0.49
Chronic steroid use	26 (3.6%)	10 (1.8%)	0.05
Chronic obstructive pulmonary disease	59 (8.1%)	22 (3.9%)	< 0.01
Moderate to severe dyspnea	62 (8.5%)	35 (6.2%)	0.12
End stage renal disease on dialysis	4 (0.5%)	4 (0.7%)	0.71

Ascites	45 (6.2%)	29 (5.2%)	0.43
Disseminated cancer	234 (32.1%)	154 (27.4%)	0.06
Hypertension	379 (52.1%)	248 (44.4%)	< 0.01
Malignant obstruction site			
Cecal cancer	59 (20.9%)	38 (17.1%)	0.28
Ascending colon cancer	41 (14.5%)	45 (20.3%)	0.09
Hepatic flexure cancer	19 (6.7%)	7 (3.2%)	0.07
Transverse colon cancer	33 (11.7%)	33 (14.9%)	0.29
Splenic flexure cancer	18 (6.4%)	7 (3.2%)	0.09
Descending colon cancer	32 (11.3%)	14 (6.3%)	0.05
Sigmoid cancer	61 (21.6%)	60 (27%)	0.15
Rectosigmoid junction	19 (6.7%)	18 (8.1%)	0.55
Wound class			
Clean/contaminated	436 (59.9%)	406 (72.2%)	< 0.01
Contaminated	164 (22.5%)	107 (19%)	0.12
Dirty	128 (17.6%)	49 (8.7%)	< 0.01
American Society of Anesthesiologists (ASA) Score			
I	12 (1.6%)	16 (2.9%)	0.14
II	142 (19.5%)	178 (31.8%)	< 0.01
III	401 (55.1%)	276 (49.3%)	0.03
IV	173 (23.8%)	90 (16.1%)	< 0.01
Pathological stage			
I	8 (1.6%)	5 (1.3%)	0.68
II	128 (26.2%)	108 (28.1%)	0.47
III	194 (39.7%)	154 (40%)	0.87
IV	159 (32.5%)	118 (30.6%)	0.59
Functional health status before surgery			
Independent	671 (93.2%)	526 (93.9%)	0.58
Partial dependency	41 (5.7%)	28 (5%)	0.94
Complete dependency	8 (1.1%)	6 (1.1%)	0.58
Other factors			
Operation length [mean ± standard deviation]	148 (±67) min	132 (±67) min	< 0.01
Preoperative leukocytosis	300 (41.4%)	198 (35.4%)	0.02
Preoperative chemotherapy	46 (6.4%)	28 (5%)	0.28
Smoking	129 (17.7%)	92 (16.4%)	0.52
Creation of a stoma	285 (39.1%)	211 (37.5%)	0.55
Minimally invasive approach	116 (15.9%)	132 (23.5%)	< 0.01
Severe hypoalbuminemia[a]	165 (27.7%)	85 (18.4%)	< 0.01

[a]Serum albumin level less than 3 g/dL

Table 3 Multivariate analysis of factors associated with morbidity of patients with malignant colonic obstruction who underwent surgery

Variable	Adjusted odd ratio	95% confidence interval	*P* value
Gender			
Female vs. male	0.64	0.49–1.07	0.11
Race			
White	Reference	Reference	–
Black or African American	0.80	0.21–2.96	0.73
Asian	0.81	0.22–2.96	0.75
Other	1.09	0.28–4.25	0.89
Comorbidity			
Hypertension	1.46	0.84–2.51	0.17
Chronic steroid use	1.21	0.52–2.79	0.65
Chronic obstructive pulmonary disease	1.53	0.84–2.76	0.15
Malignant obstruction site			
Cecal cancer	Reference	Reference	—
Ascending colon cancer	0.43	0.21–0.91	0.02
Hepatic flexure cancer	1.25	0.48–3.11	0.66
Transverse colon cancer	0.79	0.33–1.86	0.59
Splenic flexure cancer	0.48	0.11–2.11	0.33
Descending colon cancer	1.33	0.46–3.82	0.59
Sigmoid cancer	0.50	0.23–1.04	0.06
Rectosigmoid junction	0.46	0.15–1.35	0.16
Wound class			
Clean/contaminated	Reference	Reference	—
Contaminated	0.74	0.44–1.25	0.26
Dirty	3.12	1.72–5.66	<0.01
Pathological stage			
I	Reference	Reference	—
II	0.97	0.90–1.02	0.99
III	0.42	0.02–6.03	0.52
IV	0.31	0.02–3.92	0.36
American Society of Anesthesiologists (ASA) Score			
I	Reference	Reference	—
II	0.95	0.20–4.39	0.95
III	0.59	0.16–2.12	0.41
IV	0.99	0.56–1.14	0.22
Functional health status before surgery			
Independent	Reference	Reference	—
Partial dependency	0.94	0.41–2.12	0.88
Complete dependency	0.70	0.11–4.45	0.71
Other factors			
Operation length	1.006	1.003–1.010	<0.01
Preoperative leukocytosis	1.25	0.95–1.64	0.09
Smoking	1.38	0.82–2.31	0.21
Severe hypoalbuminemia[a]	1.43	1.03–1.97	0.02
Laparoscopic approach vs. open	0.67	0.48–93	0.01

[a]Serum albumin level less than 3 g/dL

Table 4 Postoperative 30-day complications of patients who underwent colectomy for colonic obstruction by surgical approach NSQIP 2012– 2016 (multivariate analysis)

Complications	Minimally invasive approach total = 249	Open approach total = 1044	Adjusted odd ratio (confidence interval)	*P* value
Mortality	8 (3.2%)	102 (9.8%)	0.51 (0.24–1.10)	0.08
Overall morbidity[a]	124 (50%)	644 (61.8%)	0.67 (0.48–0.93)	0.01
Severe morbidity[b]	62 (25%)	348 (33.4%)	0.57 (0.31–1.06)	0.08
Respiratory complications[d]	13 (5.2%)	135 (12.9%)	0.48 (0.24–0.97)	0.04
Wound complications[e]	27 (10.8%)	146 (14%)	0.68 (0.40–1.17)	0.17
Unplanned intubation	4 (1.6%)	46 (4.4%)	0.53 (0.15–1.80)	0.31
Prolonged ileus	58 (23.3%)	323 (31%)	0.76 (0.52–1.11)	0.16
Progressive renal insufficiency	1 (0.4%)	12 (1.1%)	0.45 (0.05–4.10)	0.48
Anastomosis leakage	19 (7.7%)	61 (5.9%)	1.26 (0.67–2.38)	0.46
Ventilator dependency more than 48 h	5 (2%)	52 (5%)	0.50 (0.17–1.48)	0.21
Pneumonia	7 (2.8%)	91 (8.7%)	0.40 (0.16–0.98)	0.04
Intra-abdominal infection	21 (8.4%)	74 (7.1%)	1.45 (0.81–2.61)	0.20
Superficial surgical site infection	21 (8.4%)	109 (10.4%)	0.83 (0.46–1.48)	0.54
Deep surgical site infection	5 (2%)	21 (2%)	0.45 (0.09–2.07)	0.30
Wound disruption	4 (1.6%)	25 (2.4%)	0.67 (0.14–3.10)	0.61
Sepsis	13 (5.2%)	71 (6.8%)	0.88 (0.43–1.81)	0.74
Septic shock	5 (2%)	65 (6.2%)	0.34 (0.11–1.03)	0.05
Hemorrhagic complications need transfusion	32 (12.9%)	178 (17%)	0.90 (0.56–1.45)	0.67
Unplanned reoperation	22 (8.8%)	80 (7.7%)	1.19 (0.66–2.16)	0.54
Unplanned readmission	34 (13.7%)	120 (11.5%)	1.24 (0.76–2.01)	0.37
Deep Venus thromboembolism	5 (2%)	39 (3.7%)	0.63 (0.23–1.71)	0.36
Pulmonary embolism	4 (1.6%)	21 (2%)	0.87 (0.28–2.66)	0.81
Central vascular accident (CVA)[c]	1 (0.4%)	7 (0.7%)	1.34 (0.13–13.60)	0.80
Cardiac arrest requiring CPR	1 (0.4%)	14 (1.3%)	0.98 (0.97–1)	0.99
Acute renal failure	3 (1.2%)	8 (0.8%)	3.29 (0.72–14.92)	0.12
Urinary tract infection	10 (4%)	36 (3.4%)	1.60 (0.74–3.45)	0.23
Myocardial infarction	3 (1.2%)	19 (1.8%)	0.56 (0.11–2.75)	0.48

[a]Includes: Intra-abdominal infection, sepsis, septic shock, ventilator dependency, cardiac arrest, acute renal failure, hemorrhagic complication needs transfusion, pulmonary embolism, myocardial infarction, pneumonia, central vascular accident, superficial surgical site infection, deep surgical site infection, unplanned reoperation, deep venus thromboembolism, urinary tract infection, progressive renal insufficiency, unplanned intubation, anastomosis leakage, prolonged Ileus, and wound disruption

[b]Includes: Intra-abdominal infection, septic shock, ventilator dependency, cardiac arrest, acute renal failure, pulmonary embolism, myocardial infarction, pneumonia, unplanned reoperation, unplanned intubation, and anastomosis leakage

[c]Central vascular accident/stroke with neurological deficit

[d]Includes: pneumonia, unplanned intubation, ventilator dependency

[e]Includes: superficial and deep surgical site infection and wound disruption

Mortality and morbidity of patients who underwent emergent operation for malignant obstructed colon per surgical approach are reported in Table 4. Multivariate analysis revealed the laparoscopic approach to obstructing colonic cancers was associated with lower overall morbidity (50% vs. 61.8%, AOR: 0.67, P = 0.01) and overall respiratory complications (5.2% vs.12.9%, AOR: 0.48, P = 0.04). Although severe morbidity (25% vs. 33.4%, AOR: 0.57, P =

0.08) and mortality (3.2% vs. 9.8%, AOR: 0.51, P = 0.08) rates were lower in laparoscopic approach, the difference did not reach a significant result in multivariate analysis (Table 4).

When comparing hospitalization length, the patients who underwent laparoscopic surgery had shorter hospitalization compared to open surgery (10 days vs. 13 days, mean difference: 3 days, P < 0.01).

Conversion to open surgery was observed in 28.5% of the attempted laparoscopic cases. Mortality and morbidity of patients treated for colonic obstruction by surgical approach and site of the colonic cancers are reported in Table 5. Patients who had conversion to open had a higher mortality and morbidity rates (Table 5). In multivariate analysis conversion to open did not increase mortality (AOR 1.99, CI 0.54–7.24, P = 0.29) and overall morbidity (AOR 1.51, CI 0.55–4.17, P = 0.41) of patients compared to planned open cases.

Table 5 Mortality and morbidity of patients who underwent colectomy for colonic obstruction by surgical approach and site of the colonic cancers

Obstruction site	Mortality/morbidity	Planned open (1044)	Laparoscopic overall (249)	Successfully completed laparoscopic (178)	Converted to open (71)
Cecal cancer (118)	Mortality	7.9% (6/76)	0% (0/21)	0 (0/15)	0% (0/6)
	Morbidity	64.2% (48/76)	71.4% (15/21)	73.3% (11/15)	66.7% (4/6)
Ascending colon (104)	Mortality	10.3% (7/68)	5.6% (1/18)	0 (0/15)	33.3% (1/3)
	Morbidity	58.8% (40/68)	38.9% (7/18)	33.3% (5/15)	66.7% (2/3)
Hepatic flexure cancer (34)	Mortality	16.7% (3/18)	0% (0/8)	0 (0/7)	0% (0/1)
	Morbidity	83.3% (15/18)	50% (4/8)	42.9% (3/7)	100% (1/1)
Transverse colon (79)	Mortality	9.4% (5/53)	0% (0/13)	0% (0/11)	0% (0/2)
	Morbidity	56.6% (30/53)	38.5% (5/13)	36.4% (4/11)	50% (1/2)
Splenic flexure cancer (31)	Mortality	4.8% (1/21)	0% (0/5)	0 (0/3)	0(0/2)
	Morbidity	75% (15/21)	60% (3/5)	33.3% (1/3)	100%v(2/2)
Descending colon (53)	Mortality	17.9% (7/39)	0 (0/7)	0 (0/7)	0 (0/0)
	Morbidity	71.8% (28/39)	57.1% (4/7)	57.1% (4/7)	0 (0/0)
Sigmoid colon (138)	Mortality	6.6% (7/106)	0% (0/16)	0 (0/13)	0 (0/3)
	Morbidity	57.1% (60/106)	31.3% (5/16)	23.1% (3/13)	66.7% (2/3)
Rectosigmoid colon (43)	Mortality	3.2% (1/31)	0 (0/6)	0 (0/4)	0 (0/2)
	Morbidity	58.1% (18/31)	50% (3/6)	50% (2/4)	50% (1/2)
Unknown site (942)	Mortality	10.2% (65/632)	4.5% (7/155)	4.8% (5/103)	3.8% (2/52)
	Morbidity	61.7% (390/632)	50.3% (78/155)	42.7% (44/103)	65.3% (34/52)
All operations (1542)	Mortality	9.8% (102/1044)	3.2% (8/249)	2.8% (5/178)	4.2% (3/71)
	Morbidity	61.8% (644/1044)	50% (124/249)	43.5% (77/178)	66.2% (47/71)

Discussion

This study found a rate of 19.3% for utilization of laparoscopic approach for malignant colonic obstruction for NSQIP database. Although the NSQIP database is a voluntary data set, thus it does not provide a picture of national rates, this observed rate of utilization of MIS approach in malignant colonic obstruction is significantly lower than the recent national trends for elective colectomies (55.4%) [2]. The lower rate of laparoscopic approach in this study can

be related to the long-standing dogma holding that malignant bowel obstruction should be approached in an open fashion. Malignant colonic obstruction has been considered a contraindication to perform laparoscopic surgery for a long time [10, 11]. The scientific validation and acceptance of laparoscopic approach for colorectal cancer has favorably evolved [12–14]. New guidelines of the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) and the American Society of Colon and Rectal Surgery (ASCRS) suggest that the decision to proceed laparoscopically for obstructing colon cancer should be made based on patient's condition, the extent of abdominal distension, and the oncological resectability of the carcinoma [13, 14]. Laparoscopic approach for resection of malignant colonic obstruction is a viable option and the decision on surgical approach in such operations needs to be evaluated case by case.

We found significantly lower morbidity (50% vs. 61.8%) in patients who underwent colectomy via laparoscopic approach compared to the open approach. Also, our study results show that there was a trend toward decreased mortality and severe morbidity in the laparoscopic group compared to open group that did not reach the level of statistical significance. Also, multiple complications had lower rates in patients undergoing operation via a laparoscopic approach compared to open. This is in line with previously published studies [2, 15, 16]. We found significant benefits of a laparoscopic approach in decreasing respiratory complications. Lower risk of respiratory complication can be explained with better lung ventilation as a result of less incisional pain in the postoperative period for laparoscopic surgery [17]. Even though we used multivariate analysis and we adjusted our results with multiple factors, patients undergoing open and laparoscopic colectomy for obstructing colon cancer are not two homogeneous groups of patients and drawing any firm conclusion may be with bias.

We found a significant high conversion rate to open for laparoscopic approach to obstructing malignant colon lesion (28.5%) which is higher than 12% reported national conversion rate to open for elective colectomy [1]. With increasing experience laparoscopic colectomy may be a more feasible option in colonic obstruction. Other viable approaches such as robotic approach may minimize some limitations of minimally invasive approaches. However, it seems like abdominal distention in patients with colonic obstruction is a key point for the high conversion rate to open in operations with colonic obstruction. The variation in conversion rate to open from 19% for Cecal cancer to 29.2% for sigmoid cancers in our study reinforces the necessity of colonic decompression before operation for patients with severely distended abdomen especially for left sided colonic obstructions. This decompression can be done with endoscopic stent placement preoperatively. We assume stent placement for patients with obstructed colon cancer may increase the possibility of a laparoscopic approach in the presence of obstruction. Recent guidelines introduced the possibility of initial endoscopic stent decompression and interval laparoscopic colectomy in presence of left sided obstruction with abdominal distention [13, 14]. Recent randomized prospective trials reported 78% clinical success rate of stent placement for obstructing colon cancer with a similar oncologic outcomes compared to operation without stent [18–20]. Initial stenting followed by optimization and subsequent interval colectomy is supported by European Society of Gastrointestinal Endoscopy (endorsed by the American Society of Gastrointestinal Endoscopy) and the French Society of

Digestive Endoscopy as well [21, 22]. However, there are published studies reporting an increase in local recurrence rate after stent placement compared with emergency surgery without stent [23, 24]. The strategy of preoperative stent placement to relieve obstruction can be a solution to increase the feasibility of laparoscopic approach and decrease the conversion rate of MIS procedures for colonic obstruction. This strategy needs to be evaluated by clinical trials.

We found an increase in operation length for the laparoscopic approach compared to open surgery for malignant colonic obstruction. Multiple previous studies revealed in the elective setting longer operation times for laparoscopic surgery does not increase morbidity and mortality of patients [25, 26]. However, in emergent/urgent setting prolonged operation time may be a contributor to overall morbidity. Although the mean difference in operation length of open and laparoscopic approaches in our study was only 22 min, ill patients with colonic obstruction in an emergent/urgent setting are more susceptible to perioperative complications compared to patients undergoing elective colectomy. The strategy of preoperative stent placement to relieve obstruction which can lead to an elective operation may be an appropriate solution which needs more investigation.

Study limitations

This is a retrospective study and has limitations inherent to a retrospective analysis and we are unable to draw causal conclusions. Missing data were presented for some variables of this study, although less than 5% of cases. The two groups of patients compared in this study (open vs. laparoscopic surgery) may not be two homogeneous groups of patients and although we attempted to adjust for all possible confounders, we could not capture all potentially important explanatory variables such as previous abdominal operation and severity of abdominal distention. We could not differentiate patients who had partial obstruction from patients who had complete obstruction. Also, we did not have any information if the patients had preoperative colonic stent placement or not. This study was not a closed cohort study and any analysis of trend is flawed by this fact that hospitals enter and exit the NSQIP cohort database annually and rates reported in this study do not reflect the national rates. Despite these limitations, the advantage of using the NSQIP database is the broad national geographic representation across all regions of the country and makes it a suitable database to evaluate outcomes on a national level.

Conclusion

A laparoscopic approach to malignant colonic obstruction, despite being infrequently utilized, is associated with a decrease in morbidity. However, the laparoscopic approach was used only in 19.3% of our study populations. This suggests that efforts should be directed towards increasing the availability of laparoscopic approaches for the surgical treatment of colonic obstruction. However, the high conversion rate especially in left sided colonic obstructed patients reinforces an opportunity for colonic decompression before the MIS approach. The strategy of preoperative stent placement to relieve obstruction and lead to an elective operation for patients with malignant colonic obstruction needs more investigation.

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