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The Growing Utilization of Laparoscopy in Emergent Colonic Disease

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Emergent colonic disease has traditionally been managed with open procedures. Evaluation of recent trends suggests a shift toward minimally invasive techniques in this disease setting. The American College of Surgeons National Surgical Quality Improvement Program (NSQIP) targeted colectomy database from 2012 to 2014 was used to examine clinical data from patients who emergently underwent open colectomy (OC) and laparoscopic colectomy (LC). Multivariate regression was utilized to analyze preoperative characteristics and determine risk-adjusted outcomes with intent-to-treat and as-treated approach. Of 10,018 patients with emergent colonic operation, 90 per cent (9023) underwent OC whereas 10 per cent (995) underwent LC. Laparoscopic utilization increased annually, with LC composing 10.9 per cent of emergent colonic operations in 2014 compared with 9.3 per cent in 2012. Compared with LC, patients treated with OC had higher rates of overall morbidity (odds ratio 2.01, 95% confidence interval 1.74–2.34, $P < 0.01$) and 30-day mortality (odds ratio 1.79, 95% confidence interval 1.30–2.46, $P < 0.01$). Subset analysis of emergent patients without preoperative septic shock revealed consistent benefits with laparoscopy in overall morbidity, 30-day mortality, ileus, and surgical site infection. In select patients with hemodynamic stability, emergent LC appears to be a safe and beneficial operation. This study reflects the growing preference and utilization of minimally invasive techniques in emergent colonic operations.

THE BENEFITS OF laparoscopy in elective colonic disease have been well documented in contemporary literature, including reduction in postoperative complication rates, shortened length of stay (LOS), and decreased surgical site infections (SSIs).[1] Thus, the paradigm for elective management has evolved toward increased utilization of minimally invasive techniques.[2] Historically, laparoscopic colectomy (LC) has been reserved for elective circumstances with substantial perioperative planning and patient optimization. Open technique has been the preferred approach for emergency colonic operations. Emergent conditions may reveal unfavorable circumstances such as dilated bowel, reduced intraperitoneal working space, and pneumoperitoneum intolerance due to hemodynamic instability.[3] Early retrospective studies in emergent laparoscopy have yielded equivocal results when compared with open operations.[4, 5]

Through greater familiarity with laparoscopy in recent years, the surgical community has increasingly incorporated minimally invasive techniques in emergent colonic disease.[6] Therefore, we intended to use a large database to examine national utilization rates of laparoscopy in emergent colonic pathology and to perform a risk-adjusted comparison of postoperative outcomes between open and laparoscopic emergent colonic operations.

Methods

A retrospective review of the 2012 to 2014 American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP) targeted colectomy files was performed to identify patients that underwent emergent colonic operations. ACS NSQIP is a nationally validated, risk-adjusted, outcome-based database that records detailed perioperative clinical data from surgical patients.[7] Approval for the use of this patient database was obtained from the Institutional Review Board at the University of California, Irvine Medical Center and from ACS. CPT codes were used to stratify by open and laparoscopic emergent cohorts. Patients less than 18 and those with incomplete data were excluded. CPT codes (44140–1, 3, 7, 50–51, 60) defined open colectomy (OC). CPT codes 44204–08 and 44210 defined LC. NSQIP defines emergent cases as acute, life-threatening disease mandating immediate operations with limited preparation and minimal patient optimization. Demographic and comorbidity data were examined with univariate analysis through Pearson Chi-Square testing. Risk adjusted outcomes were determined through linear and logistic regression modeling. Multivariate covariates included age, ethnicity, gender, significant patient comorbidities, preoperative wound infection, and septic shock. Key endpoints included overall morbidity, 30-day mortality, anastomotic leak, ileus, and SSI. Secondary endpoints included myocardial infarction, pneumonia, acute renal failure, organ space SSI, and unplanned reoperation and readmission. To control for preoperative hemodynamic instability, multivariate analysis was performed on a subset of emergent patients without preoperative septic shock. As-treated and intent-to-treat analyses were performed, with intent-to-treat featuring grouping of converted patients into the laparoscopic subset. Statistical analyses were performed using IBM© SPSS Statistics, Version 23.0.0.0 (Armonk, NY).

Results

From 2012 to 2014, 10,018 patients underwent emergent colectomy (Table 1). Of these patients, 90 per cent (9023) underwent OC, and 10 per cent (995) underwent LC. Mean age was 65 ± 16 years for OC compared with 60 ± 19 years in LC ($P < 0.01$). Both cohorts were similar with respect to gender, ethnicity, BMI, diabetes, congestive heart failure, (CHF), steroid use, and preoperative renal failure; the open cohort demonstrated higher rates of preoperative sepsis/septic shock, dialysis, and tobacco use (Table 2).Mean operation duration was slightly shorter with OC (133 ± 70 minutes) than LC (140 ± 75 minutes), ($P < 0.01$). Of the 995 cases of emergent LC between 2012 and 2014, 43 per cent were performed in 2014 alone. LC utilization increased between 2012 and 2014, from 9.3 to 10.9 per cent of all emergent colectomies. Perforated diverticulitis was the most common indication in the open cohort (17.8%). Colonic malignancy was the most common diagnosis in the LC group at 18.7 per cent, with obstruction as the most common emergent indication in 57.2 per cent of cases (Table 3). In cases of diverticulitis and colon cancer, OC patients more commonly received diversion. After multivariate risk adjustment in an as-treated model, OC patients demonstrated higher postoperative complication on key endpoints (Table 4). Overall morbidity rate in OC patients was 59.6 per cent compared with LC patients at 34.6 per cent (odds ratio (OR) 2.01, 95% confidence interval (CI) 1.74–2.34, P < 0.01). Thirty-day mortality rate in OC patients was 13.4 per cent compared with 4.6 per cent in LC (OR 1.79, 95% CI 1.30–2.46, P < 0.01). Higher rates of ileus and SSI were demonstrated in OC patients as well. Anastomotic leak rates were similar between the two groups. In examination of the subset population without septic shock, overall morbidity (OR 1.83, 95% CI 1.54–2.17, P < 0.01), 30-day mortality (OR 1.89, 95% CI 1.22–2.92, P < 0.01), ileus and SSI were higher for OC patients (Table 5). The subset population treated with OC demonstrated higher rates of pneumonia and unplanned readmission. Of the open cohort, 44 patients underwent conversion to OC. Intent-to treat and as-treated multivariate analysis of both the overall cohort and subset without septic shock demonstrated similar outcomes for primary and secondary endpoints (Tables 4 and 5). The OC cohort demonstrated higher overall morbidity, 30-day mortality, ileus, and SSI when compared with LC with an intent to-treat analysis. LOS in the subset without septic shock after intent-to-treat analysis was 13 ± 11.4 days for OC compared with 10 + 8.6 days for LC, P < 0.01.

TABLE 1. *Comparison of Demographic Characteristics between OC and LC. Median Age Reported with IQR*

	Open (n = 9023)	Lap (n = 995)	*P* Value
Median age (years), IQR	66 (54–77)	63 (48–75)	
Mean age (years)	65 ± 16	60 ± 19	<0.01
Gender			
Male	4197 (46.5%)	460 (46.2%)	0.86
Female	4826 (53.5%)	535 (53.8%)	0.87
Race			
Caucasian	6563 (85.1%)	697 (83.3%)	0.99
African American	937 (12.2%)	80 (9.5%)	0.7
Asian	180 (2.3%)	53 (6.3%)	0.23
Other	33 (0.4%)	7 (0.9%)	0.26
BMI			
<18.5	413 (5%)	47 (5.1%)	0.15
18.5–24.9	2716 (33.2%)	315 (34.4%)	0.27
25–30	2443 (29.9%)	289 (31.5%)	0.47
30–40	2037 (25%)	227 (24.7%)	0.98
>40	563 (6.9%)	40 (4.3%)	0.84
Most common operative diagnoses			
Diverticulitis	1604 (17.8%)	176 (17.7%)	0.95
Colon cancer	976 (10.8%)	187 (18.7%)	<0.01

BMI, body mass index; IQR, interquartile range.

TABLE 2. *Comparison of Perioperative Comorbidities and Characteristics between OC and LC*

	Open (n = 9023)	Lap (n = 995)	*P* Value
Comorbidities			
Preop septic shock	1379 (15.3%)	29 (2.9%)	<0.01
Dialysis	381 (4.2%)	16 (1.6%)	<0.01
Tobacco use	1844 (20.4%)	165 (16.6%)	<0.01
COPD	999 (11.1%)	78 (7.8%)	0.05
Hypertension	4820 (53.4%)	448 (45%)	0.2
Diabetes mellitus	1479 (16.4%)	119 (12%)	0.56
Vent. dependency	719 (8%)	18 (1.8%)	0.22
Steroid use	1167 (12.9%)	110 (11.1%)	0.99
Preop wound infection	375 (4.2%)	15 (1.5%)	0.93
Ascites	351 (3.9%)	331 (0.7%)	0.04
CHF	285 (3.2%)	17 (1.7%)	0.46
Preop renal failure	348 (3.9%)	15 (1.5%)	0.93
Mean operative time (min)	133 ± 70	140 ± 75	<0.01

COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure.

TABLE 3. *Overall Distribution of OC and LC by Diagnosis*

Emergent Diverticulitis	Open (n = 1604)	Lap (n = 176)	*P* Value
Key emergent indication			
Perforation	1398 (87.2%)	113 (64.2%)	< 0.01
Obstruction	91 (5.7%)	15 (8.5%)	0.13
Other	115 (7.1)	48 (27.2%)	
Operation performed			
No diversion	255 (16%)	96 (54.5%)	<0.01
Colostomy	1330 (83%)	79 (44.8%)	<0.01
End ileostomy	19 (1.1%)	1 (0.5%)	0.46
Emergent colon cancer	**Open (n = 976)**	**Lap (n = 187)**	***P* Value**
Key emergent indications			
Perforation	208 (21.3%)	19 (10.2%)	<0.01
Obstruction	620 (63.5%)	107 (57.2%)	0.1
Other	148 (15.1%)	61 (32.6%)	
Operation performed			
No diversion	592 (60.6%)	179 (95.7%)	<0.01
Colostomy	343 (35.1%)	6 (3.2%)	<0.01
End ileostomy	41 (4.2%)	2 (1%)	0.03

44 patients underwent conversion to OC. Intent-to-treat and as-treated multivariate analysis of both the overall cohort and subset without septic shock demonstrated similar outcomes for primary and secondary endpoints (Tables 4 and 5). The OC cohort demonstrated higher overall morbidity, 30-day mortality, ileus, and SSI when compared with LC with an intent-to- treat analysis. LOS in the subset without septic shock after intent-to-treat analysis was 13 ± 11.4 days for OC compared with 10 + 8.6 days for LC, P < 0.01.

TABLE 4. *Risk Adjusted Multivariate Analysis of Postoperative Outcomes for OC and LC. Left Table Features As-Treated Analysis and Right Table Features Intent-to-Treat Analysis*

As-Treated	Open (n = 9023)	Lap (n = 995)	AOR	95% CI	*P* Value	Intent-to-Treat	Open (n = 8979)	Lap (n = 1039)	AOR	95% CI	*P* Value
Primary endpoints						Primary endpoints					
Overall morbidity	5380 (59.6%)	344 (34.6%)	2.01	1.74–2.34	<0.01	Overall morbidity	5356 (59.7%)	368 (35.4%)	1.92	1.66–2.22	<0.01
30-day mortality	1208 (13.4%)	46 (4.6%)	1.79	1.30–2.46	<0.01	30-day mortality	1206 (13.4%)	48 (4.6%)	1.77	1.29–2.43	<0.01
Anastomotic leak	341 (3.8%)	46 (4.7%)	0.8	0.58–1.11	0.19	Anastomotic leak	339 (3.8%)	48 (4.6%)	0.8	0.58–1.10	0.18
Ileus	2965 (32.5%)	195 (19.6%)	1.68	1.42–1.99	<0.01	Ileus	2952 (32.9%)	208 (20%)	1.63	1.39–1.92	<0.01
Any SSI	1624 (18%)	96 (9.6%)	2.12	1.70–2.64	<0.01	Any SSI	1611 (17.9%)	109 (10.5%)	1.93	1.56–2.38	<0.01
Secondary endpoints						Secondary endpoints					
Myocardial infarction	189 (2.1%)	10 (1%)	1.67	0.85–3.13	0.13	Myocardial infarction	187 (2.1%)	12 (1.2%)	1.39	0.76–2.54	0.27
Pneumonia	859 (9.5%)	38 (3.8%)	1.83	1.30–2.57	<0.01	Pneumonia	856 (9.5%)	41 (3.9%)	1.77	1.27–2.46	<0.01
Acute renal failure	311 (3.4%)	8.95 (0.9%)	2.29	1.15–4.54	0.02	Acute renal failure	310 (3.5%)	10 (1%)	2.12	1.10–4.07	0.02
Organ space SSI	800 (8.9%)	59 (5.9%)	1.41	1.06–1.86	0.01	Organ space SSI	794 (8.8%)	65 (6.3%)	1.32	1.01–1.73	0.03
Hospitalization						Hospitalization					
Unplanned reoperation	711 (7.9%)	57 (5.7%)	1.22	0.91–1.62	0.16	Unplanned reoperation	708 (7.9%)	60 (5.8%)	1.2	0.91–1.58	0.19
Unplanned readmission	813 (9%)	70 (7%)	1.39	1.07–1.80	0.01	Unplanned readmission	807 (9%)	76 (7.3%)	1.32	1.02–1.69	0.03

TABLE 5. *Risk Adjusted Multivariate Analysis of Postoperative Outcomes for OC and LC in Patient Subset Without Preoperative Septic Shock. Left Table Features As-Treated Analysis and Right Table Features Intent-to-Treat Analysis*

As Treated	Open (n = 4904)	Lap (n = 781)	AOR	95% CI	*P* Value	Intent-to-Treat	Open (n = 4874)	Lap (n = 811)	AOR	95% CI	*P* Value
Primary endpoints						Primary endpoints					
Overall morbidity	2243 (45.7%)	241 (30.9%)	1.83	1.54–2.17	<0.01	Overall morbidity	2225 (45.7%)	259 (31.9%)	1.72	1.46–2.03	<0.01
30-day mortality	326 (6.6%)	24 (3.1%)	1.89	1.22–2.92	<0.01	30-day mortality	324 (6.6%)	26 (3.2%)	1.79	1.18–2.72	<0.01
Anastomotic leak	178 (3.6%)	35 (4.5%)	0.93	0.57–1.21	0.33	Anastomotic leak	177 (3.6%)	36 (4.4%)	0.84	0.57–1.21	0.35
Ileus	1323 (27%)	148 (19%)	1.49	1.23–1.81	<0.01	Ileus	1316 (27%)	155 (19.1%)	1.48	1.22–1.79	<0.01
Any SSI	822 (16.8%)	73 (9.3%)	2.06	1.59–2.66	<0.01	Any SSI	813 (16.7%)	82 (10.1%)	1.87	1.47–2.39	<0.01
Secondary endpoints						Secondary endpoints					
Myocardial infarction	87 (1.8%)	10 (1.3%)	1.25	0.64–2.44	0.5	Myocardial infarction	85 (1.7%)	12 (1.5%)	1.05	0.56–1.95	0.86
Pneumonia	296 (6%)	25 (3.2%)	1.67	1.09–2.55	0.01	Pneumonia	295 (6.1%)	26 (3.2%)	1.67	1.10–2.54	0.01
Acute renal failure	74 (1.5%)	5 (0.6%)	1.99	0.79–5.0	0.14	Acute renal failure	73 (1.5%)	6 (0.7%)	1.69	0.72–3.96	0.22
Organ space SSI	325 (6.6%)	41 (5.2%)	1.33	0.95–1.87	0.09	Organ space SSI	321 (6.6%)	44 (5.4%)	1.28	0.92–1.78	0.13
Hospitalization						Hospitalization					
Unplanned Reoperation	305 (6.2%)	50 (6.4%)	0.96	0.70 = 1.32	0.82	Unplanned Reoperation	302 (6.2%)	53 (6.5%)	0.93	0.68–1.26	0.65
Unplanned Readmission	471 (9.6%)	48 (6.1%)	1.63	1.20–2.23	<0.01	Unplanned Readmission	466 (9.6%)	53 (6.5%)	1.51	1.12–2.04	<0.01
Mean LOS, days	15 ± 13	10 ± 8	3.21	2.41–4.01	<0.01	Mean LOS, days	13 ± 11.38	10 ± 8.6	2.45	1.65–3.25	<0.01

Discussion

Our study represents a contemporary comparison of emergent minimally invasive practices against conventional open between 2012 and 2014 of the NSQIPtargeted colectomy database. Nationally, gradual increase in laparoscopic practices was noted; the 2014 LC rate of 10.9 per cent revealed an increase in use compared with Keller et al. (4.2%, 2008–2011) and Ballian et al. (9.6%, 2005–2008). After multivariate risk adjustment, emergent laparoscopy demonstrated reduction in mortality as well as key complication rates including overall morbidity, mortality, ileus, and SSI in both as-treated and intent-to-treat analysis. Subset analysis in hemodynamically stable patients without septic shock revealed key endpoint benefits with laparoscopy. Preliminary small cohort studies have illustrated the role of laparoscopy in emergent colonic disease. Champagne et al.[8] detailed a small retrospective single institution experience with emergent LC. Whereas postoperative complications in this series were quite prevalent, low reoperation and readmission rates were illustrated, conveying overall safety and feasibility. Li et al.[9] illustrated similar benefit in laparoscopic approach through a series describing laparoscopic assisted right hemicolectomy for complicated cecal diverticulitis. Bleier et al.[10] performed a comparative study between open and laparoscopic repair of iatrogenic perforations, illustrating the association of laparoscopy with reduced postoperative comorbidities. Keller et al.[11] associated these postoperative benefits in emergent minimally invasive surgery with reduction in overall hospital cost. In an earlier study from ACS NSQIP extending from 2005 to 2008, Ballian et al.[12] compared emergent open and laparoscopic restorative colectomy. Despite shorter postoperative LOS, equivalent 30-day morbidity and mortality rates were illustrated between open and laparoscopic operations. Our study illustrates substantial benefits in patients treated with LC, paralleling some of the established advantages of minimally invasive colectomy in elective circumstances as well as results from earlier single institution experiences with emergent laparoscopy.[8, 13–15] Compared with laparoscopy, the open group demonstrated higher rates of preoperative septic shock. We suspect that hemodynamic instability with ongoing shock was the basis for surgeon preference of open approach with fecal diversion. Moreover, this key comorbidity may have also profoundly impacted postoperative complications rates. Our subset multivariate analysis controlled for this confounding effect suggests that emergent laparoscopy continues to improve postoperative outcomes in hemodynamically stable patients. Thus, as evidenced by the findings of this study, we contend that with ongoing perioperative resuscitation tactics, laparoscopic intervention is still a feasible option in a cohort of more stable patients. It is plausible to also consider that a smaller subset of surgeons more adept at laparoscopy may successfully utilize a minimally invasive approach and employ lower rates of diversion. Considering the greater physiological impact of exploratory laparotomy, emergent laparoscopy may ultimately pose less intraoperative stress. Although contradictory to the negative effect of long operative duration in elective surgery, laparoscopy demonstrated lower complication rates despite slightly longer operative times.[16] To account for differences from the 2005 to 2008 nontargeted NSQIP review by Ballian et al., we believe our study illustrates growing comfort with laparoscopy by the more contemporary surgical community in 2014. Better patient selection and improvements in perioperative resuscitation tactics may also be factors. Overall, these findings do suggest that the surgical community should not employ a uniformly open operative approach with respect to emergent colonic disease, as strong consideration should be given toward identifying select patients with improved hemodynamic stability that would benefit from laparoscopy. Similar outcomes between intent-to-treat and as-treated analysis imply similarity in outcome between laparoscopic cases and converted cases, suggesting a possible role for diagnostic laparoscopy to guide open intervention. Limitations are present in our study. It is evident that a strong selection bias is present when surgeons determine surgical approaches. Our risk adjusted analytic model and subset analysis attempted to control for these factors. Details regarding frequency of 30-day antecedent operations and intraoperative conditions such as hemodynamic stability and peritoneal contamination were not available in the NSQIP database. These additional perioperative determinants that were not captured may have been contributive in choosing approach. Errors related to NSQIP coding may also be present.

Conclusion

In conclusion, our study supports selective adoption of minimally invasive surgery in colonic operations for a suitable patient subset. Emergent laparoscopy increased to 10.9 per cent of colectomies performed in 2014. These findings warrant greater consideration in emergent surgical practice as well as more in-depth analysis by means of prospective trials.

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