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Permalink

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Journal

The American surgeon, 87(4)

ISSN

0003-1348

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Publication Date

2021-04-01

DOI

10.1177/0003134820950295

Peer reviewed

Outcomes of Minimally Invasive Colectomy for Perforated Diverticulitis

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Abstract

Background: We hypothesized that a laparoscopic approach to sigmoidectomy for perforated diverticulitis is associated with less morbidity and mortality.

Methods: The NSQIP database was used to investigate adult patients who underwent emergent colectomy with end colostomy for perforated diverticulitis. A multivariate analysis using logistic regression was used to compare outcomes of patients by surgical approach.

Results: We found a total of 2937 adult patients who underwent emergent colectomy for perforated diverticulitis during 2012-2017. The rate of minimally invasive surgery (MIS) was 11.4% with 38.6% conversion rate to open. The 30-day mortality and morbidity rates were 8.8% and 65.8%, respectively. Following adjustment using a multivariate analysis, the open approach was associated with higher morbidity (67.2% vs 56.8%, AOR: 1.70, $P < .01$) and mean hospitalization length of patients (13 days vs 10 days, $P < .01$) compared to the MIS approach. Respiratory complications of ventilator dependency (14.3% vs 6%, AOR: 2.95, $P < .01$) and unplanned intubation (7.4% vs 2.4%, AOR: 2.14, $P = .03$) were significantly higher in the open approach. However, patients who underwent the open approach were older (age >70 ; 33.5% vs 24%, $P < .01$) with more comorbid conditions such as COPD (10.8% vs 7.2%, $P = .04$) and CHF (9% vs 3.1%, $P < .0$).

Conclusion: The MIS approach to emergent partial colectomy for perforated diverticulitis is associated with decreased morbidity and hospitalization length of patients. Utilization of the MIS approach for partial colectomy for perforated diverticulitis is 11.4% with a conversion rate of 38.6%. Efforts should be directed toward increasing the utilization of laparoscopic approaches for the surgical treatment of perforated diverticulitis.

Introduction

Minimally invasive colectomy, which has been shown to result in less morbidity and faster recovery compared to open surgery in an elective setting, is the current standard of care for elective management of colonic diseases.^{1,2} Recent data reveal a broad use of minimally invasive surgery (MIS) in elective colectomy for diverticulitis in the US.¹ Although benefits of the MIS approach have been established in the elective setting, the safety and possibility of this approach in nonelective colorectal resections are controversial.^{1,2}

The incidence of diverticulosis has been reported in 33%-66% of the population in western countries, increasing with age.³ Acute diverticulitis is a common reason of acute hospitalization in the US.³⁻⁵ It is reported that 10%-25% of patients with diverticulosis will develop an acute episode of acute diverticulitis.³ Overall, 85% of colonic diverticulitis will recover with nonoperative treatment.^{5,6} However, some patients may need urgent/emergent

surgical intervention for abscesses, fistulas, obstruction, and/or perforation.^{5,6} The traditional operation for acute perforated diverticulitis is the Hartmann procedure with open sigmoidectomy with a colostomy creation.⁷ However, it is associated with high morbidity and mortality rates.⁷ For this reason, it is important to explore other less invasive treatment options. Currently, the surgical community focuses on alternative surgical approaches to decrease mortality and morbidity of patients who required surgical treatment such as peritoneal lavage, primary anastomosis, and so forth.⁷ A laparoscopic approach may decrease morbidity and mortality of patients who require operation; however, this is not well established or accepted. Although the feasibility of the laparoscopic approach to sigmoidectomy has been reported in studies by experienced surgeons, such conclusions can only be generalized to the larger population of general surgeons if similar outcomes can be found in a larger study such as a national database study.⁷⁻⁹ Using a nationwide database, this study aims to investigate the rate of utilization of the MIS approach in emergent sigmoidectomy and compare 30- day outcomes of such patients with the open traditional Hartmann procedure.

Methods

A multicenter, retrospective study was carried out using the American College of Surgeons National Surgical Quality Improvement Program (ACS- NSQIP) database of clinical records of all adult patients (age 18 years and more) who had emergent sigmoid colon resection with colostomy creation (Hartman procedure) for perforated diverticulitis by surgical approach. We queried patients who underwent an emergent Hartman procedure whose data were submitted to the ACS NSQIP between January 1, 2012 and December 31, 2017. The NSQIP database is a large national database extracted from medical records by trained surgical clinical reviewers and includes more than 300 variables such as patient demographics, comorbidities, perioperative characteristics, and 30- day postoperative complications from surgical procedures performed in more than 600 participating institutions of varying sizes and academic affiliations.¹⁰ Variables considered in this study were defined as mentioned by the NSQIP User Guide, which can be referenced for detailed variable definitions online.¹⁰ Overall morbidity is defined as the presence of at least 1 of these postoperative complications: 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 venous thromboembolism, urinary tract infection, progressive renal insufficiency, unplanned intubation, prolonged ileus, and wound disruption. Severe morbidity is defined as the presence of at least 1 of these complications: intraabdominal infection, septic shock, ventilator dependency, cardiac arrest, acute renal failure, pulmonary embolism, myocardial infarction, and pneumonia. All data in NSQIP database are fully anonymized by the American College of Surgeons; this study was exempt from IRB approval.¹⁰ In this study, we selected adult patients with perforated diverticulitis who underwent the emergent Hartman procedure using existing variables of “primary indication for surgery” and “indication of operation if emergent” from NSQIP target files for 2012-2017. The procedure type was defined based on the current procedural terminology (CPT) codes of 44143 and 44206 for partial colectomy with end colostomy. Demographic data (age, sex, and race), comorbidities (such as hypertension, coagulopathy, diabetes mellitus), operative factors (such as operation length, surgical approach), and outcomes

(postoperative complications, mortality, hospitalization length, etc.) were investigated in this study. The endpoints were comparing the mortality and morbidity of patients by surgical approaches.

Statistical Analysis

Patients were divided into 2 groups as per surgical approach (open vs MIS). A univariate analysis was performed on patient demographics, comorbidities, and perioperative characteristics to determine the difference in proportions for dichotomous and categorical variables between both groups using Pearson's χ^2 test. Characteristics that resulted in a P value $<.05$ on univariate analysis were included in a multivariate logistic regression analysis to identify independent risk factors for primary adverse outcomes. The 1- way analysis of variance was used to assess difference in mean for continuous variables. P values $<.05$ were considered significant. All statistical tests were performed using the Statistical Package for Social Sciences (SPSS) software, Version 22 (SPSS Inc., Chicago, IL).

Results

We identified a total of 2937 patients who underwent emergent open or MIS sigmoidectomy with colostomy with diagnosis of acute diverticulitis with perforation between January 1, 2012 and December 31, 2017 within the NSQIP database. Most patients were Caucasian (91.2%) and male (52.1%). The most prevalent comorbidities included hypertension (54.4%) and chronic steroid use (18.1%). Patients were divided into 2 groups by surgical approach: open surgery and MIS surgery. The descriptive statistics and patient demographics by surgical approach are summarized in Table 1. Open surgery is more commonly done in older patients, those with congestive heart failure (CHF), medicated hypertensive or partial or complete dependency before operation to another person for activities of daily living (ADL).

Overall, 334 (11.4%) operations were conducted with MIS approaches. The conversion rate to open was noted in 38.6% of the cases. There was a steady increase in the utilization of the laparoscopic approach to emergent sigmoidectomy with colostomy for perforated diverticulitis during 2012-2017 from 9.2% in 2012 to 13% in 2017 (Figure 1). Mean operation duration was longer in laparoscopic operations than open operations (143 minutes vs 127 minutes, $P < .01$).

The 30- day mortality, overall morbidity, severe morbidity, and postoperative complications of patients who underwent emergent operation for perforated diverticulitis per surgical approach are reported in Table 2. The multivariate analysis revealed that the open approach to sigmoidectomy for perforated diverticulitis was associated with higher morbidity compared to the laparoscopic approach (67.2% vs 56.8%, AOR: 1.70, $P < .01$) (Table 2). There was no significant difference in risk of reoperation (8.5% vs 3.9%, AOR: 01.06, $P = .79$) or intra-abdominal abscess (11.6% vs 10.2%, AOR: 1.12, $P = .59$) of patients who underwent open versus MIS approach. Respiratory complications of ventilator dependency (14.3% vs 6%, AOR: 2.95, $P < .01$) and unplanned intubation (7.4% vs 2.4%, AOR: 2.14, $P = .03$) were significantly higher in the open approach (Table 2). Also, patients who underwent the open approach had longer hospitalization length compared to the MIS approach (13 days vs 10 days, mean difference: 3 days, $P < .01$). Conversion to open surgery occurred in 38.6% of cases. In the multivariate analysis, conversion to open surgery is associated with increased morbidity of patients compared to successfully completed MIS operations (AOR: 2.47, $P < .01$). However,

patients with conversion to open did not have higher morbidity risk compared to patients who had planned open procedures (AOR: 0.89, P = .57).

Table 1. Demographics and Clinical Characteristics of Patient Population of the Study.^a

Variables		Patients with planned open surgery Total = 2603	Patients with minimally invasive approaches Total = 334	P value
Age	Age >70 years	872 (33.5)	80 (24)	<.01
Sex	Female	1352 (51.9)	179 (53.6)	.56
Race	White	2050 (90.9)	279 (93.9)	.35
	Black or African American	170 (7.5)	14 (4.7)	.30
	Asian	26 (1.2)	3 (1)	.14
	Other	10 (0.4)	1 (0.3)	.18
Comorbidity	Diabetes mellitus with oral agents or insulin	325 (12.5)	31 (9.3)	.09
	Weight loss >10% loss body weight in last 6 months	62 (2.4)	6 (1.8)	.50
	Congestive heart failure in 30 days before surgery	80 (3.1)	3 (0.9)	.02
	Obesity	958 (39.9)	140 (44.9)	.09
	Steroid use for chronic condition	475 (18.2)	56 (16.8)	.50
	Severe chronic obstructive pulmonary disease	282 (10.8)	24 (7.2)	.04
	Moderate or Severe dyspnea	229 (8.8)	16 (4.8)	.01
	Renal failure on dialysis	62 (2.4)	4 (1.2)	.16
	Hypertension requiring medication	1438 (55.2)	159 (47.6)	<.01
	Partial or complete dependency before surgery	165 (6.4)	11 (3.3)	.02
Other factors	ASA score >2 ^b	1958 (75.3)	201 (60.4)	<.01
	Mean operation length	127 min	143 min	<.01
	Operation on admission day	1675 (57)	180 (53.9)	.22
	Transfer from another facility	42 (12.6)	484 (18.6)	<.01
	Preoperative leukocytosis >20 000 mm ³	417 (16.1)	54 (16.2)	.96
	Presence of septic shock in operation day	201 (7.7)	16 (4.8)	.04
	Current smoker within 1 year	568 (21.8)	73 (21.9)	.98
	Serum albumin level less than 3.5 mg/dL	1215 (53.4)	127 (45.4)	.01

^aValues are presented as mean (%).

^bThe American Society of Anesthesiologists score.

Figure 1. Rate of minimally invasive approach to emergent sigmoidectomy with colostomy for perforated diverticulitis per year NSQIP 2012-2017.

Table 2. Postoperative 30-Day Complications of Patients Who Underwent Emergent Colectomy With End Colostomy for Perforated Diverticulitis by Surgical Approach NSQIP 2012-2017 (Multivariate Analysis).^a

Complications	Minimally invasive approach Total = 334	Open approach Total = 2603	Adjusted odd ratio (CI)	P value
Mortality	14 (4.2)	244 (9.4)	1.73 (0.95-3.15)	.06
Overall morbidity ^b	188 (56.8)	1744 (67.2)	1.70 (1.30-2.20)	<.01
Severe morbidity ^c	89 (7.9)	1044 (40.2)	1.76 (1.29-2.40)	<.01
Ventilator dependency more than 48 hours	20 (6)	372 (14.3)	2.95 (1.68-5.15)	<.01
Prolonged ileus	90 (27.2)	895 (34.6)	1.36 (1.02-1.81)	.03
Unplanned intubation	11 (2.4)	192 (7.4)	2.14 (1.07-4.28)	.03
Pneumonia	18 (5.4)	197 (7.6)	1.53 (0.85-2.75)	.15
Intra-abdominal infection	34 (10.2)	303 (11.6)	1.12 (0.73-1.70)	.59
Superficial surgical site infection	15 (4.5)	172 (6.6)	1.69 (0.91-3.11)	.09
Deep surgical site infection	7 (2.1)	53 (2)	1.90 (0.58-6.22)	.28
Wound disruption	10 (3)	88 (3.4)	1.04 (0.51-2.14)	.89
Sepsis	72 (21.6)	505 (19.4)	1.08 (0.79-1.49)	.60
Septic shock	31 (9.3)	463 (17.8)	2.15 (1.38-3.34)	.01
Hemorrhagic complications need transfusion	26 (7.8)	430 (16.5)	2.35 (1.46-3.77)	<.01
Unplanned reoperation	13 (3.9)	268 (8.5)	1.06 (0.66-1.70)	.79
Deep venous thromboembolism	7 (2.1)	111 (4.3)	1.68 (0.77-3.67)	.19
Pulmonary embolism	2 (0.6)	43 (1.7)	2.19 (0.52-9.20)	.28
Central vascular accident (CVA)	1 (0.3)	19 (0.7)	1.82 (0.23-13.85)	.56
Cardiac arrest requiring cardiopulmonary resuscitation (CPR)	1 (0.3)	52 (2)	5.14 (0.70-37.60)	.10
Acute renal failure	4 (1.2)	70 (2.7)	2.35 (0.72-7.58)	.15
Urinary tract infection	3 (0.9)	39 (1.5)	2.01 (0.47-8.48)	.33
Progressive renal insufficiency	1 (0.3)	34 (1.3)	1.01 (0.26-3.12)	.99
Myocardial infarction	4 (1.2)	46 (1.8)	2.26 (0.54-9.48)	.26

Abbreviation: NSQIP, National Surgical Quality Improvement Program.

^aValues are presented as mean (%).

^bIncludes: 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 venous thromboembolism, urinary tract infection, progressive renal insufficiency, unplanned intubation, prolonged ileus, and wound disruption.

^cIncludes: intra-abdominal infection, septic shock, ventilator dependency, cardiac arrest, acute renal failure, pulmonary embolism, myocardial infarction, pneumonia.

Discussion

Our study results show that a minimally invasive approach to the Hartman procedure in emergent setting is associated with decreased morbidity of patients compared to an open approach. It was also shown that there was a trend toward decreased mortality in the laparoscopic group compared to the open group that did not reach the level of statistical significance ($P = .06$). The practice guideline of the American Society of Colon and Rectum Surgeons (ASCRS) recommends the laparoscopic approach to elective colectomy for diverticulitis (high- quality evidence, 1A).¹¹ Although the majority of published reports included patients with uncomplicated disease, the surgical literature and the guideline considered the laparoscopic approach to complicated diverticulitis as well.¹¹ This study reinforces previously published articles' finding of less morbidity of the laparoscopic approach to perforated diverticulitis.¹¹⁻¹³ However, the utilization of the laparoscopic approach for perforated diverticulitis is limited compared to the elective setting (11.4% of this study result vs 68.2% in a

previous published study).¹ The difference in the utilization of the laparoscopic approach can be related to either the surgeon's preference or comfort level for the open approach or technical challenges of laparoscopic surgery in the presence of perforation and inflammation or also to perceived risk due to patient comorbidities. The heterogeneous laparoscopic skills of surgeons can be improved with nationwide or regional training programs to prepare practicing surgeons to perform more advanced laparoscopic colon procedures. Also, reviewing/explaining the advantages of laparoscopic surgery in educational meetings may increase the adoption of laparoscopic surgery. We found a significant decrease in the risks of overall morbidity, severe morbidity, unplanned intubation, ventilator dependency, hemorrhagic complications, prolonged ileus, and septic shock using the laparoscopic approach compared to open. Benefits of the laparoscopic approach in colorectal surgery have been discussed broadly in the literature.^{1,14,15} The lower risk of respiratory complications of the laparoscopic approach can be explained with better lung ventilation as a result of less incision pain in the postoperative period for laparoscopic surgery.¹⁶ The mechanism of diminished ileus has been explained in the literature with activating a pro-inflammatory cascade within intestinal tissues with the end effect of suppression of bowel muscle function.^{17,18} The laparoscopic approach could reduce the inflammatory process and decrease the risk of postoperative prolonged ileus.^{18,19} However, our results of less morbidity for the laparoscopic approach compared to open need to be confirmed with prospective clinical trials. Comparing open and laparoscopic approaches to perforated diverticulitis may be confounded by selection bias. The baseline characteristics of the participants in this study (open vs laparoscopic surgery) were heterogeneous (Table 1). We found patients who underwent the laparoscopic approach were younger with less comorbid conditions and better function health status before operation. Although we adjusted our results for multiple factors, we may not capture all potentially important explanatory variables and drawing any firm conclusion may be with bias. This finding shows there is a trend to operate with open approach for sicker patients with perforated diverticulitis which might be for shorter operation length. Prospective clinical trials need to compare outcomes of open and laparoscopic approaches to perforated diverticulitis in 2 homogeneous groups of patients.

Our study results reveal a conversion to open rate of 38.6% for the laparoscopic approach to perforated diverticulitis which is higher than the 11.5%-37% reported in the literature.^{8,20-22} Previously published studies are mostly with experienced surgeons at 1 institution and the higher rate of conversion in our study is likely related to the nationwide data of this study with different levels of expertise in laparoscopic colectomy. A decrease in the conversion rate could be achieved with increasing experience of surgeons and advances in dissection devices.²³ Hassan et al reported that long-term patient outcomes are not adversely impacted by laparoscopic surgery for complicated diverticulitis patients requiring conversion to an open procedure.²¹ In this regard, our study results show that patients with conversion to open did not have a higher morbidity risk compared to patients who had planned open procedures. Also, advancement in dissection and coagulation devices may facilitate laparoscopic-assisted sigmoid resection and decrease the conversion rate.²³

We found longer operation time with shorter hospitalization for the patients who underwent the laparoscopic approach to perforated diverticulitis compared to open. Previous published studies have revealed longer operation time for laparoscopic surgery but this does not increase morbidity and mortality of patients in elective setting.^{24,25} However, in the emergent/urgent setting, prolonged operation time may be more of a concern. Advancement in dissection and coagulation devices and increased experience of surgeons over time may facilitate

laparoscopic sigmoid resection and shorten the operation length.²³ However, the mean difference in the operation length of open and laparoscopic approaches in our study was only 16 minutes. Shorter hospitalization length is 1 of the general advantages of laparoscopic approach, which has been previously cited multiple times and can result in reduced costs per patient.^{7,24,25}

Study Limitations

We acknowledge the limitations of this study. This is a retrospective study and we are unable to draw causal conclusions. The baseline characteristics of the participants in this study (open vs laparoscopic surgery) were heterogeneous and although we attempted to adjust the results with all possible confounders, we could not capture all potentially important explanatory variables such as previous abdominal operation and Hinchey classification for perforated diverticulitis.²⁶ In addition, using the NSQIP database, only short-term (30 days from surgery) outcomes can be measured, which rely on nurse data extractors and phone call follow-up evaluation.¹⁰ Despite these limitations, the advantage of using the NSQIP database is the broad national geographic representation across all regions of the country and this makes it a suitable database to evaluate outcomes at the national level.

Conclusion

The MIS approach to emergent partial colectomy for perforated diverticulitis when feasible is associated with decreased morbidity and hospitalization length of patients. There is a significant decrease in risks of unplanned intubation, ventilator dependency, hemorrhagic complications, prolonged ileus, and septic shock using the laparoscopic approach compared to open for perforated diverticulitis. The utilization of the MIS approach to partial colectomy for perforated diverticulitis is 11.4% with an increasing rate over time. Conversion to open is common (38.6%), but patients with conversion have similar mortality and morbidity compared to patients who underwent planned open procedures.

Author Note

Accepted for oral presentation at the 61st Annual Meeting of Society for Surgery of the Alimentary Tract (SSAT): May 2-5, 2020: Chicago, IL, USA.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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