A comparison of outcomes of emergent, urgent, and elective surgical treatment of diverticulitis

Zhobin Moghadamyeghaneh, M.D., Joseph C. Carmichael, M.D., Brian R. Smith, M.D., Steven Mills, M.D., Alessio Pigazzi, M.D., Ninh T. Nguyen, M.D., Michael J. Stamos, M.D.*

Department of Surgery, University of California, Irvine, School of Medicine, Irvine, CA, USA

Abstract

BACKGROUND: There is a controversy regarding the best urgent surgical treatment of colonic diverticulitis. We sought to compare outcomes of patients who underwent surgery for diverticulitis by the type of admission.

METHODS: The National Surgical Quality Improvement Program databases were used to examine the clinical data of patients who underwent colorectal resection for diverticulitis during 2012 to 2013. Multivariate regression analysis was performed to identify outcomes of patients.

RESULTS: We sampled a total of 13,510 patients admitted for diverticulitis who underwent colorectal resection, of which 7.8% had emergent and 19.7% had urgent operation. Patients with perforation (adjusted odds ratio [AOR] 188.56, P < .01) and preoperative sepsis (AOR 28.17, P < .01) had significantly higher rates of emergent surgery. Patients who underwent emergent operation had higher mortality (AOR 4.08, P = .04) and morbidity (AOR 2.14, P< .01). Emergent operations had a significantly higher risk of anastomosis leakage compared with elective operation (AOR 3.92, P = .02).

CONCLUSIONS: Emergent treatment of diverticulitis is associated with a high morbidity and mortality. In the setting of emergent treatment of diverticulitis, colonic anastomosis without a stoma has a high risk of anastomosis leakage.

KEYWORDS: Diverticulitis; Colonic diverticulitis; Emergent surgical treatment

Diverticulosis is among the most common gastrointestinal conditions which has had a dramatic increase over the past few decades. Approximately one third of the US population has diverticulosis and 20% of these patients develop diverticulitis.[1,2] Patients with diverticulitis are at a lifetime risk for emergency colectomy and colostomy. It is important to recognize factors that predict patients for whom emergent surgery is likely to allow consideration of an earlier elective operation when possible.

Overall, 19% of diverticulitis patients need surgical treatment[2] and emergency operation is required in 18% of those patients who need surgery.[2] However, given the risk of colostomy during an emergent operation, elective colectomy has been recommended for many patients who recover from nonsurgically treated episodes of diverticulitis. [2] Identifying high-risk patients for emergent surgery and considering elective resection in such high-risk patients may decrease mortality and morbidity. However, there are limited data regarding predictors of high-risk patients who may require emergent surgery.

Emergent surgical treatment of diverticulitis is associated with higher mortality and morbidity compared with elective treatment.[3] Also, the standard emergent surgical treatment of diverticulitis, which is a sigmoid colectomy and colostomy (Hartmann's procedure), is associated with high morbidity. Therefore, many studies investigating the surgical options suggest avoiding colostomy for diverticulitis patients,[4] observing that urgent treatment of diverticulitis compared with emergent treatment may decrease postoperative complications of patients as well as the need for colostomy. However, there are limited published data investigating outcomes of patients with urgent treatment of diverticulitis.

The standard urgent/emergent treatment of diverticulitis is the resection of the diverticula affected colonic segment and formation of a colostomy.[3,5] However, a colostomy increases the morbidity rate of patients. To decrease morbidity, alternative surgical methods have been explored which include colonic resections with primary anastomosis but with or without diverting ileostomy and colonic lavage.[3,4,6,7] However, the role of primary anastomosis with or without a stoma as an alternative procedure remains unsettled.[3,8,9] Although guidelines for emergent surgical treatment of sigmoid diverticulitis by the American Society of Colon and Rectal Surgeons suggest possible alternatives to Hartmann's procedure, such as primary anastomosis with or without intraoperative colonic lavage, the role and safety of primary anastomosis remains unclear and the

traditional Hartmann's procedure is commonly performed by surgeons.[8] A nationwide study comparing different types of urgent/emergent surgical treatment of diverticulitis is lacking. Using a nationwide database, this study aims to report outcomes of emergent, urgent, and elective surgical treatment of diverticulitis and compare different types of procedures used for the treatment of diverticulitis.

Patients and Methods

This study was performed utilizing the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database during 2012 to 2013.[10] The American College of Surgeons NSQIP is a large validated outcome-based program which provides preoperative to 30-day postoperative surgical outcomes based on clinical data to improve the quality of surgical care in the United States.[10] This study evaluated patients with diagnosis of diverticulitis who underwent colon resections using the appropriate procedural and diagnosis codes as specified by the International Classification of Diseases, 9th Revision, clinical modifications and Current Procedural Terminology. Patients who had colonic diverticulitis were defined based on the International Classification of Diseases, 9th Revision, clinical modification diagnostic code 562.11. Patients who had colon resection were defined based on the following Current Procedural Terminology codes: 44140 to 44147, 44204 to 44208, 45110, and 45113. Patients who underwent colon surgery without colon resection and patients younger than 18 years were excluded from this study. We categorized patients into 3 groups of elective, emergent, and urgent operations according to the original variables of NSQIP.

Preoperative factors that were analyzed include patient characteristics (age, sex, and race) and comorbid conditions which include diabetes mellitus with oral agents or insulin, history of congestive heart failure within 30 days before surgery, history of severe chronic obstructive pulmonary disease, renal failure with need of dialysis, weight loss, history of dyspnea within the 30 days before surgery, bleeding disorder, steroid use within the past 30 days, preoperative sepsis (systemic inflammatory response syndrome or sepsis or septic shock within 48 hours before surgery), current smoker within 1 year, ascites (presence of fluid accumulation in the peritoneal cavity noted on physical examination, abdominal ultrasound, or abdominal computed tomography/magnetic resonance imaging before the operation), and hypertension requiring medication. Operative factors analyzed include the following: type of operation (emergent vs urgent vs elective), presence of colon perforation as the indication of surgery, surgical approach (open vs laparoscopic), type of procedure (colectomy with or without anastomosis), the American Society of Anesthesiologists (ASA) score, and operation length. Preoperative laboratory value of white blood cell (WBC) count (cells $\times 10^9$/L) was also investigated. Outcomes investigated include the following: 30-day mortality, overall morbidity, postoperative surgical site infection (superficial, deep incisional, and organ space), wound disruption, deep vein thrombosis, septic shock, pneumonia, unplanned intubation, anastomosis leakage, prolonged ileus, ventilator dependency more than 48 hours, pulmonary embolism, cardiac arrest requiring cardiopulmonary resuscitation, hemorrhagic complications, urinary tract infection, myocardial infarction, acute renal failure, unplanned reoperation, unplanned readmission, and prolonged hospitalization (longer than 30 days). The overall rates of each complication according to the type of surgery were examined. Risk-adjusted analysis was performed to compare outcomes of patients with different types of admission (emergent vs urgent vs elective). Male sex, age less than 70, Caucasian race, and elective operation were used as reference data points for comparison in line with the literature.

Statistical analysis

Statistical analysis was performed with the SPSS software, Version 22 (SPSS, Inc, Chicago, IL). Logistic regression analysis was used to estimate the association between preoperative types of surgery and each outcome, including in-hospital mortality and all the considered postoperative complications. P values less than .05 were considered statistically significant. For each outcome, the adjusted odds ratio (AOR) with a 95% confidence interval was calculated and reported to estimate the relative risk associated with the types of surgery (emergent, urgent, and elective). Adjustments were made for hypertension, diabetes mellitus, chronic obstructive pulmonary disease, congestive heart failure, ASA score, weight loss, steroid use, preoperative sepsis, ascites, dyspnea, renal failure with need of dialysis, WBC count, bleeding disorder, perforation of colon,

surgical technique (laparoscopic vs open), type of surgery (emergent, urgent, and elective), type of procedure, age, sex, and race.

Table 1 Demographics of patients with diagnosis of diverticulitis who underwent colorectal resection

Variables	Emergent surgery (1,060)	Urgent surgery (2,662)	Elective surgery (9,788)
Age (year)			
Mean ± SD	62 ± 14	61 ± 14	58 ± 12
Median	62	62	58
Sex (%)			
Female	565 (53.3)	1,432 (53.8)	5,299 (54.1)
Race (%)			
White	854 (90.9)	2,238 (89.3)	8,527 (91.8)
Black or African American	69 (7.3)	206 (8.2)	598 (6.4)
Asian	14 (1.5)	34 (1.4)	91 (1)
Others	3 (.3)	28 (1.1)	68 (.7)
Comorbidity (%)			
Hypertension	551 (52)	1,401 (52.6)	4,329 (44.2)
ASA > 2*	719 (67.9)	1,642 (61.8)	3,177 (32.5)
Chronic obstructive pulmonary disease	87 (8.2)	218 (8.2)	299 (3.1)
Steroid use	150 (14.2)	258 (9.7)	312 (3.2)
Renal failure with need of dialysis	19 (1.8)	32 (1.2)	27 (.3)
Diabetes mellitus	132 (12.5)	342 (12.8)	916 (9.4)
Bleeding disorder	111 (10.5)	234 (8.8)	155 (1.6)
Dyspnea	87 (8.2)	165 (6.2)	457 (4.7)
Weight loss	25 (2.4)	110 (4.1)	180 (1.8)
Congestive heart failure	17 (1.6)	45 (1.7)	17 (.2)
WBC†			
Mean ± SD (cells × 10^9/L)	13.71 ± 6.36	11.20 ± 5.83	7.57 ± 2.69
Median (cells × 10^9/L)	13.20	10	7.10
Other factors (%)			
Preoperative sepsis‡	672 (63.4)	1,078 (40.5)	141 (1.4)
Perforation of colon	917 (86.5)	0	0
Ascites§	28 (2.6)	28 (1.1)	6 (.1)
Operation length			
Mean ± SD (minutes)	134 ± 60	149 ± 73	183 ± 84
Median (minutes)	124	134	170
Surgical technique (%)			
Laparoscopic surgery	86 (8.1)	1,071 (40.2)	7,047 (72)
Open surgery	974 (91.9)	1,591 (59.8)	2,741 (28)
Procedure (%)			
Colon resection with anastomosis	174 (16.4)	1,117 (42)	9,249 (94.5)
Colon resection with colostomy	886 (83.6)	1,545 (58)	539 (5.5)

ASA = American Society of Anesthesiologists; CT = computed tomography; MRI = magnetic resonance imaging; SD = standard deviation; WBC = white blood cell.

*The ASA score more than 2.

†Serum white cell blood count (cells × 10^9/L).

‡Systemic inflammatory response syndrome or sepsis or septic shock within 48 hours before surgery.

§Presence of fluid accumulation in the peritoneal cavity noted on physical examination, abdominal ultrasound, or abdominal CT/MRI before the operation.

Results

A total of 13,510 patients who underwent colon resection for the diagnosis of diverticulitis during 2012 to 2013 were identified. The median age of patients was 59 years old; the majority of the patients were Caucasian (91.3%) and female (54%). Most common comorbidities included hypertension (46.5%) and diabetes (10.3%). Demographic data of patients have been reported in Table 1.

Among patients who underwent colon resection, 1,060 (7.8%) had emergent surgery, 2,662 (19.7%) had urgent surgery, and 9,788 (72.5%) had elective surgery. The most common procedure for patients who underwent elective surgery was resection with anastomosis but without ileostomy or colostomy (94.5%). Also, the colon resection without anastomosis but with a colostomy procedure was the most common procedure for patients who underwent emergent (83.6%) and urgent surgery (58%).

The mortality rate for patients who underwent emergent, urgent, and elective colon resection were 6.9%, 3.5%, and .2% respectively. In multivariate analysis of data, patients who underwent emergent surgery had a significantly higher mortality risk compared with elective surgery (Table 2).

Postoperative complications associated with emergent/urgent operation are reported in Table 2. Overall, morbidity of patients who underwent emergent (AOR 2.14, P < .01) and urgent operations (AOR 1.51, P < .01) were higher than elective operations. Patients who underwent emergent operation had higher risk of prolonged hospitalization (AOR 3.21, P = .04) and hemorrhagic complications (AOR 2.08, P = .02). Also, patients who underwent urgent operation had higher risk of prolonged hospitalization (AOR 2.47, P = .01) and hemorrhagic complications (AOR 2.10, P <.01). Also, the risk of anastomosis leakage was significantly higher in emergent operations compared with elective operations (AOR 3.92, P = .02).

The risk-adjusted analysis for factors associated with emergent surgery is reported in Table 3. Patients who were admitted with preoperative sepsis (AOR 28.17, P < .01) or colon perforation (AOR 188.56, P < .01) had higher likelihood of requiring an emergent surgery. Also, comorbidities of ascites (AOR 28.15, P < .01) had significant associations with the need for emergent surgery.

Overall, 202 patients had postoperative anastomosis leakage, of which 130 patients (64.3%) needed reoperation, 49 patients (24.2%) were treated with interventional radiology, and 23 patients (11.3%) were treated without operation or any intervention in the management of anastomosis leakage.

Mortality predictors of diverticulitis patients who underwent surgery are reported in Table 4. Factors such as ASA score more than 2 (AOR 6.48, P < .01), presence of fluid accumulation in the peritoneal cavity (AOR 5.69, P < .01), and emergent operation (AOR 4.08, P<, .01) had associations with mortality.

Finally, risk-adjusted analysis for postoperative complications by surgical approach is reported in Table 5. The laparoscopic approach decreased the risk of mortality of patients in emergent (AOR .91, P < .01) and urgent operations (AOR .15, P< .01). Also, the laparoscopic approach decreases the risk of morbidity of patients in elective (AOR .43, P < .01), urgent (AOR .62, P = .01), and emergent operations (AOR .62, P 5 .04). Factors such as preoperative perforation of colon (OR .03, P < .01), emergent surgery (OR .05, P < .01), urgent surgery (OR .14, P < .01), preoperative sepsis (OR .06, P < .01), ASA score more than 2 (OR .34, P < .01), and preoperative ascites (OR .09, P< .01) had negative associations with laparoscopic surgery.

Table 2 Risk-adjusted analysis of outcomes of emergent and urgent surgical treatment compared with elective surgical treatment of diverticulitis

Complication	Elective surgery (%)	Urgent surgery			Emergent surgery		
		Rate (%)	AOR and 95% CI	*P* value	Rate (%)	AOR and 95% CI	*P* value
Mortality	.2	3.5	1.95 (.60–6.27)	.26	6.9	4.08 (1.02–16.38)	.04
Overall morbidity	22.6	48.3	1.51 (1.25–1.84)	<.01	61.3	2.14 (1.43–3.20)	<.01
Hospitalization > 30 days	.5	3.6	2.47 (1.20–5.06)	.01	4.4	3.21 (1.02–10.05)	.04
Hemorrhagic complications	3.5	13.1	2.10 (1.48–2.97)	<.01	14.5	2.08 (1.10–3.91)	.02
Prolonged ileus	7.6	21.2	1.71 (1.32–2.21)	<.01	29.8	2.01 (1.26–3.19)	<.01
Return to operation room	4.1	6.2	1.11 (.73–1.68)	.60	8.2	2.13 (1.08–4.21)	.02
Unplanned readmission	7.3	10.1	1.37 (1.02–1.86)	.03	10.2	1.66 (.91–3)	.09
Pneumonia	.7	4.1	1.26 (.56–2.82)	.56	5.8	6 (2.23–16.17)	<.01
Ventilator dependency	.6	6.2	1.96 (.82–4.70)	.13	9.8	5.31 (1.92–14.67)	<.01
Wound disruption	.9	2.5	1.92 (.93–4)	.07	3.8	4.16 (1.31–13.20)	.01
Anastomosis leakage*	3	3.9	1.07 (.60–1.91)	.79	5.3	3.92 (1.24–12.39)	.02
Septic shock	.6	5.8	1.80 (.82–3.95)	.13	8.9	3.85 (1.42–10.45)	<.01
Acute renal failure	.2	1.1	1.16 (.24–5.59)	.84	2.3	1.06 (.12–9.15)	.95
Myocardial infarction	.2	.7	.20 (.03–1.31)	.09	.7	.54 (.05–5.35)	.60
Unplanned intubation	.5	3.3	2.25 (.91–5.53)	.07	5.7	2.65 (.71–9.92)	.14
Deep vein thrombosis	.5	1.8	1.46 (.59–3.60)	.40	3.1	1.43 (.38–5.41)	.59
Organ space SSI	3.5	7	1.01 (.65–1.58)	.93	8.1	1.83 (.88–3.80)	.10
Superficial SSI	6.2	6.5	.80 (.56–1.14)	.22	6.6	.81 (.39–1.65)	.56
Deep incisional SSI	.9	1.7	1.33 (.61–2.90)	.46	2.5	1.74 (.49–6.15)	.39
Central vascular accident	.1	.3	1.15 (.12–1.5)	.89	.3	.16 (.01–12)	.71
Pulmonary embolism	.3	.9	1.53 (.47–4.98)	.47	1.5	.19 (.01–5.05)	.32
Cardiac arrest	.1	.6	8.56 (.72–1.01)	.08	1.2	.1 (.01–20)	.71
Urinary tract infection	1.9	2.4	1.05 (.58–1.88)	.87	2.4	.66 (.19–2.22)	050

SSI = surgical site infection.
*Subanalysis of data in patients who had anastomosis without colostomy.

Table 3 Risk adjustment analysis of factors increasing the risk of emergent surgery in patients with diverticulitis

Factors	Adjusted odds ratio	95% confidence interval	*P* value
Sex			
Male	Reference	–	
Female	.80	.53–1.21	.29
Age			
≤70	Reference	–	
>70	2.46	1.55–3.90	<.01
Comorbidity			
Hypertension	.66	.42–1.03	.07
ASA > 2*	3.11	1.98–4.89	<.01
Chronic obstructive pulmonary disease	1.56	.66–3.69	.31
Steroid use	.66	.29–1.51	.33
Renal failure with need of dialysis	6.58	1.67–25.85	<.01
Diabetes mellitus	1.05	.57–1.93	.86
Bleeding disorder	2.58	1.03–6.43	.04
Dyspnea	.34	.12–1	.06
Weight loss	1.39	.48–3.98	.53
Congestive heart failure	.19	.02–1.56	.12
Other factors			
Preoperative sepsis†	28.17	16.58–47.85	<.01
Perforation of colon	188.56	25.52–1,392	<.01
Ascites‡	28.15	3.02–261	<.01
WBC	1.15	1.10–1.20	<.01

ASA = American Society of Anesthesiologists; CT = computed tomography; MRI = magnetic resonance imaging; WBC = white blood cell count.

*The American Society of Anesthesiologists score more than 2.

†Systemic inflammatory response syndrome or sepsis or septic shock within 48 hours before surgery.

‡Presence of fluid accumulation in the peritoneal cavity noted on physical examination, abdominal ultrasound, or abdominal CT/MRI before the operation.

Comments

Both emergent and urgent operations for treatment of diverticulitis have associations with significant increase in morbidity of patients. Also, emergent surgery significantly increases mortality risk of diverticulitis patients. Our study results show that the mortality risk associated with emergent surgical treatment is more than 4 times compared with elective operations. Also, the risk for 8 postoperative complications is higher in emergent operations. Urgent treatment is also associated with an increase in morbidity (by 51%). However, mortality risk of urgent surgical treatment of diverticulitis is not significantly higher than elective operations. The difference in indications of emergent, urgent, and elective surgical treatments of diverticulitis make any conclusion difficult. Further clinical trials are indicated to see if postponing an emergent surgical treatment for a couple of days in possible cases can decrease mortality and morbidity of patients.

Emergent surgical treatment of diverticulitis is associated with 61% morbidity rate. We found a significantly increased risk of 8 postoperative complications in emergent surgical treatment. Poor outcomes of emergent surgical treatment of diverticulitis have been previously reported.[2,11] Further studies should be planned to see if postponing the operation for a couple of days or laparoscopic approach can decrease morbidity of such patients.

Colon resection with a stoma is the safest strategy for patients who underwent emergent surgical treatment of diverticulitis. Although only 16.6% of emergently operated diverticulitis patients in our study had a primary anastomosis without a stoma, such patients had a significantly higher risk of anastomosis leakage compared with patients who underwent primary anastomosis without a stoma in elective setting (5.3% vs 3%, $P < .01$). Considering that a significant number of patients who had anastomotic leakage needed reoperation in

management of their leak in our study (64%), primary anastomosis without a stoma in emergent operations carries a significant risk of anastomotic leak and reoperation. We confirm the reports of colon resection with a stoma as a safe choice for emergent treatment of diverticulitis by previous studies.[12,13]

Colon resection with anastomosis but with or without an ileostomy should be evaluated for patients who underwent urgent surgical treatment of diverticulitis. This study did not find any significant difference in risk of anastomosis leakage in elective and urgent treatment of diverticulitis. It seems that primary anastomosis can be used selectively in the urgent setting. Considering the low possibility of reanastomosis of the colon after the Hartmann procedure (55%)[14] and also recently published studies favoring primary anastomosis with diverting ileostomy over theHartmann procedure,[5,12] primary colon anastomosis with or without an ileostomy should be evaluated in the urgent setting. This is in line with the latest guideline of the American Society of Colon and Rectal Surgeons which suggests primary anastomosis with proximal diversion as an optimal strategy for selected patients with complicated diverticulitis.[13] Further clinical trial studies are indicated to check if the Hartmann procedure as the standard emergent surgical treatment of diverticulitis can be replaced by primary anastomosis with an ileostomy in urgent operations.

Eight preoperative factors increase the risk of emergent surgery need in diverticulitis patients. We found that preoperative factors such as perforation of colon, sepsis, fluid accumulation in the peritoneal cavity, high WBC count, ASA score more than 2, and renal failure with need of dialysis have strong associations with the need for emergent surgery for diverticulitis patients. Presence of colon perforation and preoperative sepsis are 2 most important indications of emergent surgery in diverticulitis patients.[15] Also, American Society of Colon and

Table 4 Risk adjustment analysis of factors associated with mortality of patients with diverticulitis who underwent surgical treatment

Factors	Adjusted odds ratio	95% confidence interval	*P* value
Sex			
Male	Reference	Reference	Reference
Female	.81	.50–1.32	.41
Age			
≤70	Reference	Reference	Reference
>70	3.89	2.34–6.45	<.01
Comorbidity			
Hypertension	.73	.43–1.23	.24
ASA > 2*	6.48	2.22–18.90	<.01
Chronic obstructive pulmonary disease	1.55	.80–3.01	.19
Steroid use	2.87	1.70–4.82	<.01
Renal failure with need of dialysis	1.94	.50–7.52	.33
Diabetes mellitus	1.04	.55–1.93	.90
Bleeding disorder	1.85	1.03–3.32	.03
Dyspnea	2.52	1.34–4.76	<.01
Weight loss	2.45	.91–6.63	.07
Congestive heart failure	.30	.06–1.53	.14
Approach			
Laparoscopic	Reference	Reference	Reference
Open	1.14	.48–2.273	.75
Surgery			
Elective	Reference	Reference	Reference
Urgent	1.95	.60–6.27	.26
Emergent	4.08	1.02–16.38	.04
Other factors			
Preoperative sepsis†	3.31	1.77–6.16	<.01
Perforation of colon	1.22	.44–3.35	.69
Ascites‡	5.69	2.21–14.64	<.01
WBC	.97	.93–1.01	.15
Operation length	1.003	1.001–1.007	.02

ASA = American Society of Anesthesiologists; CT = computed tomography; MRI = magnetic resonance imaging; WBC = white blood cell count.

*The American Society of Anesthesiologists score more than 2.

†Systemic inflammatory response syndrome or sepsis or septic shock within 48 hours before surgery.

‡Presence of fluid accumulation in the peritoneal cavity noted on physical examination, abdominal ultrasound, or abdominal CT/MRI before the operation.

Rectal Surgeons reported that medical management is more likely to fail in patients with renal failure with need of dialysis as they have a significantly greater risk of recurrence.[13] Early surgical treatment in patients with mentioned risk factors should be studied by clinical trials.

Nine perioperative factors have associations with mortality of diverticulitis patients who underwent surgical treatment. Our study results show in patients who underwent surgical treatment the highest mortality risks exist in ASA score more than two among comorbid conditions, emergent surgery among surgical factors, and preoperative presence of fluid accumulation in the peritoneal cavity among other factors. Also, factors such as age more than 70 years, chronic steroid use, preoperative sepsis, and high preoperative WBC count increase mortality risk of patients. Chronic steroid use, ASA score, and age have been reported as important mortality predictors of patients who underwent operation previously.[16,17] Considering the irreducible nature of the mortality predictors, further studies are indicated to see if early surgical treatment in patients with multiple mortality risk factors can decrease mortality of such patients.

Our study results show that the laparoscopic approach decreases the morbidity risks of diverticulitis patients undergoing elective, urgent, and emergent operations. Also, we found in the emergent/urgent setting that laparoscopic approach also decreases mortality risk. Although the benefits of utilization of laparoscopic approach in colorectal surgery have been reported previously,[18] our results show that laparoscopic approach was the selected surgical approach in only 8.1% of emergent and 21.5% of urgent operations of diverticulitis. When investigating factors which have effects on choosing the surgical approach in the treatment of diverticulitis, we found factors such as preoperative perforation of colon, need to emergent/urgent operation, ASA score more than 2, preoperative sepsis, and preoperative fluid accumulation in the peritoneal cavity to have negative associations with choosing laparoscopic surgery. Further studies are indicated to understand the selection and outcomes of laparoscopic surgery in the mentioned situations.

Table 5 Risk-adjusted analysis of outcomes of emergent, urgent, and elective surgical treatment of diverticulitis in laparoscopic approach compared with open approach

	Elective surgery		Urgent surgery		Emergent surgery	
Complication	AOR and 95% CI	*P* value	AOR and 95% CI	*P* value	AOR and 95% CI	*P* value
Mortality	1.13 (.27–4.79)	<.86	.15 (.05–.42)	<.01	.91 (.89–.93)	<.01
Overall morbidity	.43 (.37–.50)	<.01	.62 (.43–.90)	.01	.62 (.38–.99)	.04
Prolonged ileus	.41 (.33–.52)	<.01	.63 (.39–1.01)	.05	.85 (.49–1.48)	.57
Hemorrhagic complications	.59 (.42–.84)	<.01	.45 (.22–.91)	.02	.19 (.05–.66)	<.01
Return to operation room	.63 (.46–.86)	<.01	.58 (.24–1.36)	.21	.42 (.13–1.27)	.12
Wound disruption	.23 (.11–.48)	<.01	.20 (.02–1.69)	.14	.82 (.20–3.34)	.78
Deep vein thrombosis	.33 (.15–.73)	<.01	3.33 (.66–16.8)	.14	.68 (.08–5.46)	.71
Superficial SSI	.37 (.29–.47)	<.01	.99 (.48–2.02)	.98	.60 (.19–1.87)	.38
Deep incisional SSI	.30 (.16–.57)	<.01	.55 (.12–2.48)	.44	1.04 (.20–5.31)	.95
Unplanned readmission	.71 (.56–.91)	<.01	.80 (.45–1.41)	.44	.91 (.41–2)	.82
Hospitalization > 30 days	.34 (.14–.82)	.01	.54 (.14–2.07)	.37	.95 (.93–.96)	.03
Organ space SSI	.70 (.50–.99)	.04	.81 (.35–1.87)	.62	.97 (.41–2.29)	.94
Ventilator dependency	1.16 (.43–3.12)	.76	.47 (.08–2.56)	.38	.89 (.87–.91)	<.01
Acute renal failure	.26 (.05–1.33)	.10	.26 (.06–1.12)	.05	.91 (.90–.93)	.14
Myocardial infarction	.70 (.19–2.59)	.60	.99 (.98–.99)	.02	.99 (.98–1)	.43
Septic shock	.87 (.36–2.06)	.75	.37 (.06–2.24)	.28	.13 (.01–1.02)	.05
Unplanned intubation	.77 (.26–2.25)	.63	.23 (.02–2.04)	.19	.27 (.03–2.15)	.21
Pneumonia	.46 (.20–1.03)	.06	.23 (.02–2.51)	.23	1.35 (.44–4.12)	.58
Central vascular accident	.09 (.08–1.04)	.05	.99 (.99–1)	.13	.99 (.99–1)	.60
Anastomosis leakage*	.74 (.50–1.09)	.13	.27 (.06–1.13)	.07	1.14 (.11–11.59)	.91
Pulmonary embolism	.73 (.25–2.11)	.56	.45 (.03–5.98)	.54	.95 (.11–8.07)	.96
Cardiac arrest	.97 (.18–5.01)	.97	.22 (.03–1.71)	.11	.98 (.97–1)	.28
Urinary tract infection	.68(.43–1.08)	.10	.37 (.10–1.39)	.14	.38 (.03–4)	.42

AOR = adjusted odds ratio; CI = confidence Interval; SSI = surgical site infection.
*Subanalysis of data in patients who had anastomosis without colostomy.

Study limitations

This study is a retrospective database review and is subject to typical biases for retrospective studies such as selection bias. Data in this study were extracted from the NSQIP database which collects data from over 500 hospitals in the United States, and there is a wide variation in hospital setting, hospital quality, surgical strategy, and surgeons' expertise that can confound the study. Also, coding errors in collecting of data may exist because of the use of discharge data in NSQIP database.[19] Although we included factors such as preoperative sepsis, preoperative colonic perforation, and preoperative presence of fluid accumulation in the peritoneal cavity to evaluate severity of disease, we did not have any information regarding Hinchey classifications to evaluate severity of diverticulitis in our patients precisely.[20] This study only evaluated information of diverticulitis patients who underwent colon resection. However, diversion or lavage and drainage are still options in the treatment of diverticulitis in specific cases and we did not have information regarding these treatment methods.[6] This study evaluated postoperative complications of diverticulitis patients and although there was no significant complication (myocardial infarction and cardiac arrest) intraoperatively, some events such as cardiac arrest and myocardial infarction may have happened during the preoperative period and we did not have any information regarding preoperative events. For all variables in the study, the missing data were lower than 5% of all cases except for the ''perforation of colon'' variable which has 45% missing data. Despite these limitations, this study is one of the limited numbers of nationwide reports on contemporary outcomes of emergent, urgent, and elective surgical treatment of diverticulitis.

Conclusion

Emergent/urgent operative treatment of colonic diverticulitis is observed in 27.5% of patients who underwent operative treatment. About 83.6% of diverticulitis patients who underwent emergent operations and 58% of patients who underwent urgent operations underwent resection with a stoma. However, outcome of patients operated on emergently/urgently is still suboptimal, with significant morbidity and mortality. Patients with colonic perforation and preoperative sepsis have higher risk to treat emergently. Patients who have a high WBC count and ASA score on admission have a high rate of emergent surgery. Early elective treatment in such high-risk patients should be further studied. The risk of anastomosis leakage in emergent operations is significantly higher than elective operations. However, there is no significant difference in the risk of anastomosis leakage between elective and urgent operations. Primary anastomosis with an ileostomy may be the optimal strategy for patients with diverticulitis in the urgent setting. Further clinical studies are indicated to evaluate if the Hartmann procedure as the standard emergent surgical treatment of diverticulitis can be replaced by primary anastomosis with an ileostomy in urgent setting.

References

1. Roberts P, Abel M, Rosen L, et al. Practice parameters for sigmoid diverticulitis. The Standards Task Force American Society of Colon and Rectal Surgeons. Dis Colon Rectum 1995;38:125–32.
2. Anaya DA, Flum DR. Risk of emergency colectomy and colostomy in patients with diverticular disease. Arch Surg 2005;140:681–5.
3. Hupfeld L, Burcharth J, Pommergaard HC, et al. The best choice of treatment for acute colonic diverticulitis with purulent peritonitis is uncertain. Biomed Res Int 2014;2014:380607.
4. Lee EC, Murray JJ, Coller JA, et al. Intraoperative colonic lavage in nonelective surgery for diverticular disease. Dis Colon Rectum 1997;40:669–74.
5. Oberkofler CE, Rickenbacher A, Raptis DA, et al. A multicenter randomized clinical trial of primary anastomosis or Hartmann's procedure for perforated left colonic diverticulitis with purulent or fecal peritonitis. Ann Surg 2012;256:819–26; discussion, 826–7.
6. Myers E, Hurley M, O'Sullivan GC, et al. Laparoscopic peritoneal lavage for generalized peritonitis due to perforated diverticulitis. Br J Surg 2008;95:97–101.
7. Liang S, Russek K, Franklin Jr ME. Damage control strategy for the management of perforated diverticulitis with generalized peritonitis: laparoscopic lavage and drainage vs. laparoscopic Hartmann's procedure. Surg Endosc 2012;26:2835–42.

8. Rafferty J, Shellito P, Hyman NH, et al. Practice parameters for sigmoid diverticulitis. Dis Colon Rectum 2006;49:939–44.
9. Binda GA, Karas JR, Serventi A, et al. Primary anastomosis vs nonrestorative resection for perforated diverticulitis with peritonitis: a prematurely terminated randomized controlled trial. Colorectal Dis 2012;14: 1403–10.
10. National Surgical Quality Improvement Program [Home Page on the Internet]. Chicago, IL: American College of Surgeons; 2005 Available at: www.acsnsqip.org; 2005. Accessed January 17, 2015.
11. Vermeulen J, Coene PP, Van Hout NM, et al. Restoration of bowel continuity after surgery for acute perforated diverticulitis: should Hartmann's procedure be considered a one-stage procedure? Colorectal Dis 2009;11:619–24.
12. Constantinides VA, Heriot A, Remzi F, et al. Operative strategies for diverticular peritonitis: a decision analysis between primary resection and anastomosis versus Hartmann's procedures. Ann Surg 2007;245: 94–103.
13. Feingold D, Steele SR, Lee S, et al. Practice parameters for the treatment of sigmoid diverticulitis. Dis Colon Rectum 2014;57:284–94.
14. Pearce NW, Scott SD, Karran SJ. Timing and method of reversal of Hartmann's procedure. Br J Surg 1992;79:839–41.
15. Stocchi L. Current indications and role of surgery in the management of sigmoid diverticulitis. World J Gastroenterol 2010;16:804–17.
16. Chapman J, Davies M, Wolff B, et al. Complicated diverticulitis: is it time to rethink the rules? Ann Surg 2005;242:576–81; discussion, 581–3.
17. Ballian N, Rajamanickam V, Harms BA, et al. Predictors of mortality after emergent surgery for acute colonic diverticulitis: analysis of National Surgical Quality Improvement Project data. J Trauma Acute Care Surg 2013;74:611–6.
18. Moghadamyeghaneh Z, Masoomi H, Mills SD, et al. Outcomes of conversion of laparoscopic colorectal surgery to open surgery. JSLS 2014;18.
19. Lorence DP, Ibrahim IA. Benchmarking variation in coding accuracy across the United States. J Health Care Finance 2003;29:29–42.
20. Hinchey EJ, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. Adv Surg 1978;12:85–109.