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Predictive factors of mortality after colectomy in ischemic colitis: an ACS-NSQIP database study

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ABSTRACT

Background Surgical intervention for ischemic colitis is associated with significant postoperative morbidity and mortality. Predictive factors of adverse outcomes have been reported in the literature, but are based on small sample populations. We sought to identify risk factors for mortality after emergent colectomy for ischemic colitis using a clinical outcomes database.

Methods The American College of Surgeons National Surgical Quality Improvement Project database was queried from 2010 to 2015 to identify emergent colectomies performed for ischemic colitis using Current Procedural Terminology and International Classification of Diseases, Ninth Revision codes. Univariate and multivariate logistic regression analysis was used to identify independent risk factors associated with increased risk of mortality.

Results A total of 4548 patients undergoing emergent colectomies for ischemic colitis were identified. Overall, 30-day postoperative mortality was 25.3%. On univariate analysis, preoperative risk factors associated with a higher rate of mortality include dyspnea, functional status, ventilator dependency, history of chronic obstructive pulmonary disease, ascites, congestive heart failure exacerbation, hypertension, dialysis dependency, cancer, open wounds, chronic steroids, weight loss >10%, transfusions within 72 hours before surgery, septic shock and duration from hospital admission to surgery. Factors that were significant for mortality on logistic regression analysis include elderly age, poor functional status, multiple comorbidities, septic shock, blood transfusion, acute renal failure and the duration of time from hospital admission to surgery.

Conclusions Postoperative morbidity and mortality rates for ischemic colitis remain significantly high. Identification of risk factors may help patient selection for surgical interventions, and make informed decisions with patients and family members. Although it is certainly challenging, early diagnosis and prompt surgical intervention for patients with ischemic colitis may improve outcomes.

Study type and level of evidence Therapeutic/care management, level II

INTRODUCTION

Ischemic colitis is a common and potentially lethal disease of the gastrointestinal tract with high rates of postoperative morbidity and mortality. Its clinical presentation is variable and often non-specific, and its course ranges from mild self-limiting forms to gangrene, perforation and intra-abdominal sepsis, requiring surgical intervention.[1] Without signs that prompt escalation of care, such as gastrointestinal bleeding, peritonitis or worsening acidosis, early diagnosis and intervention can be challenging.[2 3]

Approximately 14%–66% of patients diagnosed with ischemic colitis require surgery,[2–6] with up to two-thirds of these patients undergoing an emergent operation.[7] Postoperative mortality rates are significant, ranging from 5% to over 80%.[2 5 6 8–10] This wide variation in mortality has been studied by others, who have identified some risk factors including advanced age, male gender, coronary artery disease, atrial fibrillation, recent cardiovascular surgery and history of dialysis.[1 3 4 6 7 9–11] Clinical predictors of mortality include abdominal tenderness, signs of peritonitis, absence of gastrointestinal bleeding, intraperitoneal free fluid, lactic or metabolic acidosis, preoperative hemodynamic instability, perioperative vasopressors, need for mechanical ventilation and surgical delay >3 days.[3 4 6 8 10–13] Other studies also identified laterality of ischemia, extent of surgical resection and etiology of ischemia on specimen pathology to be predictive of mortality as well.[9]

Studies on patients undergoing colectomies for ischemic colitis have been generally limited to small, retrospective, single-center studies with <200 cases per study. These studies also combined both emergent and non-emergent operations. Considering the significant adverse outcomes associated with ischemic colitis, we sought to identify predictive risk factors for mortality and complications after emergent colectomy for ischemic colitis using the American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) database.

METHODS

Data collection

ACS-NSQIP is a national database of clinical information collected from participating hospitals. It contains blinded, risk-adjusted data regarding complication rates and surgical outcomes, and places hospitals against a national benchmark. Variables include preoperative risk factors, intraoperative variables and 30-day postoperative mortality and morbidity outcomes. The data are collected by trained surgical clinical reviewers by chart review, coded into variables with strict, rigorous definitions and then de-identified for public use.

The ACS-NSQIP databases from 2010 to 2015 were filtered for patients undergoing emergent surgery. A total of 4548 colectomies performed for ischemic colitis were identified. Current Procedural Terminology (CPT) codes were used to identify

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colectomies (CPT codes 44204, 44205, 44206, 44207, 44208, 44210, 44211, 44212, 44188, 44140, 44141, 44143, 44144, 44145, 44146, 44147, 44150, 44151, 44155, 544156, 44157, 44158, 44160, 44120, 44121, 44125, 44130). International Classification of Diseases, Ninth Revision (ICD-9) codes were used to identify the diagnosis of ischemic colitis (ICD-9-CM 557.0, 557.1, 557.9). From this population, preoperative demographic data were obtained, including age, gender, race, body mass index and comorbidities. Preoperative lab values and clinical variables such as days from admission to operation, renal failure, need for dialysis, emergency status and wound classification were obtained. Information regarding the type, laterality and extent of surgery were derived from CPT codes when unequivocal. Postoperative mortality and morbidities, such as cardiovascular, pulmonary, renal, septic and venous thromboembolic complications were analyzed. A comorbidity index was created by summing the unweighted number of comorbidities captured by the ACS-NSQIP database. Patients were divided into two cohorts—survivors and non-survivors—based on 30-day postoperative mortality.

Statistical analyses

Normally distributed continuous variables were described as mean±SD deviation, and non-normally distributed continuous variables were described by median and IQR. Categorical variables were listed in absolute numbers and percent prevalence (%) in the study group. Statistical analyses were performed between survivors and non-survivors using the IBM SPSS software, V.22.0 (SPSS, Armonk, New York, USA). Independent two sample t-tests were used to assess normally distributed continuous variables for significance, and the Mann-Whitney U test was used to assess non-normally distributed continuous and ordinal variables. Categorical variables were compared using the X^2 test. After identifying variables that were statistically significant on univariate analysis, preoperative variables that were clinically relevant were analyzed with a multivariate logistic regression model.

RESULTS

Patient characteristics

A total of 4548 patients underwent an emergent colectomy with a primary diagnosis of ischemic colitis in the 2010–2015 ACS-NSQIP database. Demographic characteristics are listed in table 1. Of all patients, 42.5% were male and 57.4% were female. The majority of patients were elderly, with 22.5% older than 80% and 41.6% aged 65–80 (data not shown); 78.4% were white, 11.0% were black, 1.4% were Asian, 0.6% were American Indian/Alaskan, 0.2% were Hawaiian/Pacific Islander and 8.4% were listed as 'other'. There were no significant differences between survivors and non-survivors in terms of race and ethnicity.

Operatively, the majority of cases were performed open (95.7%) as opposed to laparoscopic (4.3%) per CPT code (table 1). Most cases involved partial colectomies (84.4%) compared with total (15.6%). Sixty-four per cent of partial colectomies involved the right colon, and 36% involved the left. A primary anastomosis was performed in 63% of cases, while an ostomy was created in 35.5% of cases; 1.5% of cases had both an anastomosis and an ostomy done in the initial operation. The rates of valid data are listed in table 1.

Compared with patients in the survivor cohort, non-survivors were older (72.0±12.6 vs 67.3±14.7, p<0.001), and had higher rates of dyspnea at rest and moderate exertion (12.6% vs 5.1% and 11.8% vs 9.0%, p<0.001, respectively), total or partial functional dependency (14.7% vs 5.5% and 14.5% vs 9.8%, p<0.001, respectively), ventilator dependency (38.5% vs 11.2%, p<0.001), history of severe chronic obstructive pulmonary disease (25.1 vs 15.7%, p<0.001), ascites (8.3% vs 5.1%, p<0.001), congestive heart failure exacerbation within 30 days of surgery (11.0% vs 5.3%, p<0.001), hypertension requiring medications (77.0% vs 70.2%, p<0.001), acute renal failure within 24 hours prior to surgery (14.0% vs 7.8%, p<0.001), dialysis 2 weeks prior to surgery (18.1% vs 8.9%, p<0.001), disseminated cancer (4.0% vs 2.3%, p<0.001), open or infected wounds (9.7% vs 5.6%, p<0.001), chronic steroid use (11.1% vs 8.7%, p=0.013), weight loss >10% (6.7% vs 3.5%, p=0.013), transfusions within 72 hours before surgery (15.9% vs 8.0%, p<0.001) and preoperative septic shock (52.2% vs 23.1%, p<0.001).

Non-survivors were more likely to have an open operation (98.5% vs 94.6%, p<0.001) and a total colectomy (20.3% vs 13.8%, p<0.001). There was no significant difference in terms of laterality (p=0.392). The rate of ostomy creation versus primary anastomosis did not differ between cohorts (p=0.944).

Postoperative outcomes

The 30-day postoperative mortality rate following emergent colectomy for ischemic colitis was 25.3%. Comparisons of postoperative complications categorized by survivors and non-survivors are shown in table 2. The most common complications were prolonged intubation (35.2%), septic shock (26.3%) and pneumonia (13.5%). Compared with survivors, non-survivors had a higher rate of respiratory complications, such as pneumonia (16.5% vs 12.5%, p<0.001), unplanned intubation (15.6% vs 9.2%, p<0.001) and prolonged intubation >48 hours (46.1% vs 31.5%, p<0.001). Non-survivors had higher rates of septic shock (46.6% vs 19.4%, p<0.001) and lower rates of sepsis (7.0% vs 11.3%, p<0.001). Renal complications were also higher, including acute renal failure (13.0% vs 3.7%, p<0.001). Rates of cerebrovascular accident, cardiac arrest and myocardial infarction were higher in non-survivors (3.3% vs 1.5%, p<0.001, 15.6% vs 1.2%, p<0.001, 4.9% vs 3.1%, p<0.001, respectively).

Multivariate regression

Table 3 reports the results of the multivariate logistic regression analysis. Factors associated with higher odds of 30-day mortality include age, comorbidity index, functional status, preoperative septic shock, preoperative renal failure, transfusions prior to surgery and days from hospital admission to surgery.

In our analysis, the OR for mortality progressively increased with advancing age. Patients aged 65–79 years had a 235% higher odds of mortality than those aged <40 years (OR 3.36, 95% CI 1.96 to 5.74), and patients aged 80 years or older had 413% higher odds of mortality (OR 5.13; 95% CI 2.97 to 8.86). Like age, the odds of death increased with the number of comorbidities. Patients with four or more comorbidities had 345% higher odds of mortality compared with those with none (OR 4.45, 95% CI 3.06 to 6.47). Preoperative clinical factors such as septic shock, blood transfusions and acute renal failure also had increased odds of mortality (OR 2.8, 95% CI 2.39 to 3.29; OR 1.4, 95% CI 1.11 to 1.76; OR 3.06, 95% CI 2.32 to 4.03, respectively). Compared with patients who went immediately into surgery on the day of admission, those who went to surgery 1 or 2 days after admission had no increased odds of mortality (OR 0.99, 95% CI 0.82 to 1.20; OR 1.04, 95% CI 0.78 to 1.38).

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Table 1 Preoperative and intraoperative characteristics of patients with ischemic colitis

Characteristics	Total, n (%)	Survivors, n (%)	Non-survivors, n (%)	P value
Age	68.5±14.33	67.33±14.68	71.97±12.60	<0.001
Sex				0.381
Male	1936 (42.5)	1460 (43)	476 (41.4)	
Female	2609 (57.4)	1935 (56.9)	674 (58.6)	
Race/ethnicity				0.309
White	3565 (78.4)	2669 (78.5)	896 (77.9)	
Black or African-American	501 (11.0)	381 (11.2)	120 (10.4)	
Asian	64 (1.4)	49 (1.4)	15 (1.3)	
American Indian/Alaskan	27 (0.6)	22 (0.6)	5 (0.4)	
Hawaiian/Pacific Islander	9 (0.2)	8 (0.2)	1 (0.1)	
Other	382 (8.4)	269 (7.9)	113 (9.8)	
Body mass index	28.35±8.03	28.50±7.95	27.90±8.24	0.036
Diabetes	1210 (26.6)	878 (25.8)	332 (28.9)	0.044
Smoker	1140 (25.1)	845 (24.9)	295 (25.7)	0.596
Dyspnea				<0.001
At rest	319 (7.0	174 (5.1)	145 (12.6)	
Moderate exertion	441 (9.7)	305 (9.0)	136 (11.8)	
Functional status				<0.001
Independent	3628 (81.2)	2841 (84.7)	787 (70.8)	
Partial dependent	491 (10.8)	330 (9.8)	161 (14.5)	
Totally dependent	348 (7.7)	185 (5.5)	163 (14.7)	
Vent dependency	824 (18.1)	381 (11.2)	443 (38.5)	<0.001
History of severe chronic obstructive pulmonary disease	824 (18.1)	535 (15.7)	289 (25.1)	<0.001
Ascites	269 (5.9)	174 (5.1)	95 (8.3)	<0.001
Congestive heart failure	306 (6.7)	179 (5.3)	127 (11)	<0.001
Hypertension	3272 (71.9)	2387 (70.2)	885 (77.0)	<0.001
Preoperative acute renal failure	425 (9.3)	264 (7.8)	161 (14.0)	<0.001
Preoperative dialysis	510 (11.2)	302 (8.9)	208 (18.1)	<0.001
Disseminated cancer	123 (2.7)	77 (2.3)	46 (4.0)	0.002
Open or infected wounds	302 (6.6)	191 (5.6)	111 (9.7)	<0.001
Chronic steroid use	423 (9.3)	295 (8.7)	128 (11.1)	0.013
Weight loss >10%	195 (4.3)	118 (3.5)	77 (6.7)	<0.001
Bleeding disorder	178 (3.9)	130 (3.8)	48 (4.2)	0.523
Preoperative systemic sepsis				<0.001
Systemic Inflammatory Response Syndrome (SIRS)	570 (12.5)	475 (14.0)	95 (8.3)	
Sepsis	1328 (29.2)	1021 (30.1)	307 (26.7)	
Septic shock	1383 (30.4)	783 (23.1)	600 (52.2)	
Transfusions 72 hours before OR	454 (10.0)	271 (8.0)	183 (15.9)	<0.001
Preoperative Na	137.5±4.93	137.38±4.69	137.08±5.53	<0.001
Preoperative blood urea nitrogen	32.5±22.28	29.99±20.99	39.91±24.24	<0.001
Preoperative creatinine	1.90±1.65	1.77±1.62	2.26±1.68	<0.001
Preoperative white blood cells	15.38±8.51	15.19±8.05	15.95±9.71	0.010
Preoperative hematocrit	36.53±7.41	37.03±7.27	35.03±7.58	<0.001
Preoperative platelet	299.1±107.21	233.69±101.91	215.49±120.58	<0.001
Preoperative PTT	35.12±14.74	33.85±13.94	38.45±16.20	<0.001
Preoperative INR	1.45±0.76	1.36±0.66	1.68±0.93	<0.001
Operative time	110.44±70.13	111.47±70.80	107.40±68.04	0.089
Total length of stay	11, IQR (7–19)	12, IQR (8–21)	8, IQR (3–16)	<0.001
Days from admission to operation	1, IQR (0–2)	0, IQR (0–1)	1, IQR (0–3)	<0.001

Continued

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Table 1 Continued

Characteristics	Total, n (%)	Survivors, n (%)	Non-survivors, n (%)	P value
Wound classification				
One clean	46 (1.0)	33 (1.0)	13 (1.1)	<0.001
Two clean/contaminated	1039 (22.8)	842 (24.8)	197 (17.1)	
Three contaminated	1590 (35.0)	1252 (36.8)	338 (29.4)	
Four dirty/infected	1873 (41.2)	1271 (37.4)	602 (52.3)	
American Society of Anesthesiologists classification				<0.001
1	33 (0.7)	33 (1.0)	0	
2	322 (7.1)	312 (9.2)	10 (0.9)	
3	1434 (31.5)	1284 (37.8)	150 (13.0)	
4	2272 (50.0)	1556 (45.8)	716 (62.3)	
5	476 (10.5)	210 (6.2)	266 (23.1)	
Surgical approach*				<0.001
Ex-lap	2763 (95.7)	1971 (94.6)	792 (98.5)	
Laparoscopic	125 (4.3)	113 (5.4)	12 (1.5)	
Extent of colectomy†				<0.001
Partial	2437 (84.4)	1796 (86.2)	641 (79.7)	
Total	451 (15.6)	288 (13.8)	163 (20.3)	
Laterality of colectomy‡				0.392
Right hemicolectomy	753 (64.0)	558 (63.3)	195 (66.1)	
Left hemicolectomy	423 (36.0)	323 (36.7)	100 (33.9)	
Ostomy or anastomosis§				0.944
Ostomy only	894 (35.5)	654 (35.5)	240 (35.7)	
Anastomosis only	1585 (63.0)	1161 (63.0)	424 (63.0)	
Anastomosis with ostomy	36 (1.5)	28 (1.5)	9 (1.3)	

*n=2888, 63.5%.
†n=2888, 63.5%.
‡n=1176, 25.9%.
§n=2516, 55.3%.

However, patients who went to surgery 3 days or later had a 39% higher odds of mortality (OR 1.39, 95% CI 1.14 to 1.70).

The model fit the observed data well as tested using the C statistic (C=0.76) and the Hosmer-Lemeshow test (p=0.549). The C statistics represents the area under the receiver-operating curve. In the Hosmer-Lemeshow test, p value >0.05 signifies that the model fits the observed data.

DISCUSSION

Ischemic colitis can present with a wide variety of clinical pictures, ranging from self-limiting observation to surgical intervention. Rates of surgical treatment vary throughout the literature, from 14% to 66% in published studies.[2–6] Unfortunately, postoperative morbidity and mortality rates remain high, from 5% to over 80%.[2 5 6 8–10] On our analysis of ACS-NSQIP hospitals, patients undergoing emergent colectomy for ischemic colitis had a 30-day postoperative mortality rate of 25.3%. This number lies within range of previously reported rates in smaller sample populations. Patients also had high rates of postoperative complications including prolonged intubation (35.2%), pneumonia (13.5%), septic shock (26.3%) and acute renal failure (6.0%). These findings highlight the severity of the disease and its dismal outcomes after surgical intervention.

Prior studies have identified multiple risk factors predictive of mortality, such as advanced age, male sex, history of coronary artery disease and atrial fibrillation, history of peripheral vascular disease, prior cardiovascular surgery and dialysis dependence.[1 3 4 6 7 9–11] However, these studies were generally retrospective, single center, based on sample sizes of <200, and included both emergent and elective operations. We performed an analysis of the ACS-NSQIP database based on a large, robust sample population from over 600 hospitals across the nation, and selectively analyzed patients who underwent emergent surgery. In our study, patient characteristics significant for mortality on multivariate analysis include elderly age, poor functional status, multiple comorbidities, preoperative acute renal failure, preoperative septic shock, preoperative blood transfusion and notably, duration of time from hospital admission to surgery.

In the ACS-NSQIP population, operating on patients 3 days or later after their presentation to the hospital resulted in a 39% higher odds of 30-day postoperative mortality. This finding has rarely been studied in published literature; in a retrospective study of 50 patients, Noh *et al* demonstrated a 73.3% mortality rate vs 34.3% mortality rate when surgery was delayed for >3 days.[10] Unfortunately, due to the inherent limitations of the database, we cannot tell if this is a delay in diagnosis, surgical consultation or surgical intervention. Regardless, this finding highlights the importance of early diagnosis for ischemic colitis. Prompt surgical intervention is warranted, and may even prevent clinical deterioration into septic shock and renal failure, which are factors that also conferred increased odds of mortality in our study. The duration of time from hospital admission to surgery

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Table 2 30-day outcomes of colectomy for ischemic colitis

	Total, n (%)	Survivors, n (%)	Non-survivors, n (%)	P value
Mortality	1150 (25.3)	–	–	–
In-hospital	945 (20.8)	–	–	–
Wound complications				
Superficial SSI	242 (5.3)	229 (6.7)	13 (1.1)	<0.001
Deep SSI	79 (1.7)	68 (2.0)	11 (1.0)	0.019
Organ/space SSI	269 (5.9)	210 (6.2)	59 (5.1)	0.192
Wound disruption	117 (2.6)	101 (3.0)	16 (1.4)	0.003
Respiratory complications				
Pneumonia	614 (13.5)	424 (12.5)	190 (16.5)	0.001
Unplanned intubation	502 (11.0)	312 (9.2)	190 (16.5)	<0.001
Vent >48 hours	1599 (35.2)	1069 (31.5)	530 (46.1)	<0.001
Renal complications				
Progressive renal insufficiency	101 (2.2)	73 (2.1)	28 (2.4)	0.569
Acute renal failure	275 (6.0)	125 (3.7)	150 (13.0)	<0.001
UTI	206 (4.5	171 (5.0)	35 (3.0)	0.005
Cardiovascular complications				
Pulmonary embolism	39 (0.9)	37 (1.1)	2 (0.2)	0.004
Stroke/CVA	88 (1.9)	50 (1.5)	38 (3.3)	<0.001
Cardiac arrest	221 (4.9)	42 (1.2)	179 (15.6)	<0.001
Myocardial infarction	163 (3.6)	107 (3.1)	56 (4.9)	0.007
DVT	154 (3.4)	125 (3.7)	29 (2.5)	0.061
Postoperative bleeding/transfusions	1725 (37.9)	1103 (32.5)	622 (54.1)	<0.001
Sepsis complications				
Sepsis	465 (10.2)	384 (11.3)	81 (7.0)	<0.001
Septic shock	1194 (26.3)	658 (19.4)	536 (46.6)	<0.001
Return to OR	652 (14.3)	463 (13.6)	189 (16.4)	0.019
Unplanned reoperation	364 (11.7)	264 (11.3)	100 (12.8)	0.266

CVA, cerebrovascular accident; DVT, deep vein thrombosis; SSI, surgical site infection; UTI, urinary tract infection.

Table 3 Multivariate model showing predictive factors for 30-day mortality following colectomy for ischemic colitis

		95% CI		
Variable	OR	Lower	Upper	P value
Age group (years)				
18–40	Reference			
41–64	1.68	0.98	2.90	0.061
65–79	3.36	1.96	5.74	<0.001
>80	5.13	2.97	8.86	<0.001
Comorbidities				
0	Reference			
1	1.76	1.23	2.51	0.002
2	2.65	1.87	3.76	<0.001
3	3.10	2.15	4.47	<0.001
>4	4.45	3.06	6.47	<0.001
Functional status				
Independent	Reference			
Partially dependent	1.29	1.03	1.61	0.026
Fully Dependent	1.65	1.28	2.13	<0.001
Septic shock (preoperative)	2.80	2.39	3.29	<0.001
Transfusions (preoperative)	1.40	1.11	1.76	0.005
Renal failure (preoperative)	3.06	2.32	4.03	<0.001
Days to surgery				
0	Reference			
1	0.99	0.82	1.20	0.939
2	1.04	0.78	1.38	0.795
>3	1.39	1.14	1.70	0.001

represents a potentially modifiable risk factor that should be strongly emphasized and further studied.

Laterality and extent of ischemia have previously been identified as predictors of postoperative mortality. For example, a study by Genstorfer *et al* found a 3.8 and 11 times OR for death in right-sided colitis and pan colitis compared with left, respectively.[9] Longstreth and Yao found a 14.6 times OR for death in right-sided and bilateral colitis together when compared with left-sided colitis.[3] In contrast, our large sample database study showed that there was no significant difference in laterality of colectomy between survivors and non-survivors. However, non-survivors were also more likely to have total colectomies compared with survivors. Overall, our study findings are more robust with their larger sample size, but are limited by the extrapolation of laterality and extent of surgical resection from CPT code as opposed to the operative report.

Similar to prior studies, elderly patients with poor functional status and multiple comorbidities had higher rates of death.[3 5 6 14–16] Those older than 80 years carried the worst prognosis of all factors assessed in the database, with 413% higher odds of mortality. The odds of mortality increased progressively with the number of comorbidities present, up to 345% higher in patients with four or more comorbidities. Interestingly, our study showed that male gender was not a significant predictor of mortality (p=0.381). This stands in contrast to other small, single-center studies by Hughier *et al* and Longstreth and Yao that found higher rates of death with males.[3 6] Although these factors are not modifiable, this knowledge can be used to aid key stakeholders to make informed decisions regarding optimal surgical care.

The lack of gastrointestinal bleeding has been identified as a risk factor for death in multiple previous publications.[5 6 16] For example, studies by Hughier *et al*, Paterno *et al*, Moszkowicz *et al* and Añón *et al* found that the absence of rectal bleeding was a risk factor for surgery, delayed operation and death.[5 6 11 17] Likewise, the presence of rectal bleeding was protective and conferred better outcomes per Longstreth and Yao.[3] On the other hand, our study demonstrated that patients who received blood transfusions within 72 hours before surgery had higher rates of postoperative death; this has also been described in other studies.[7] These findings appear to be incongruent. Unfortunately, the ACS-NSQIP database does not capture information regarding preoperative gastrointestinal bleeding, nor does it describe indications for blood transfusion, for example, massive gastrointestinal bleeding, shock or low hemoglobin and hematocrit levels after a lengthy hospital course. One explanation is that patients without evidence of frank gastrointestinal bleeding have delays in diagnosis and surgical intervention; blood transfusions may also represent a delay in diagnosis, prolonged hospital course or hemorrhagic shock, all of which led to poor outcomes.

The strength of our study stems from the ACS-NSQIP database's robust sample size and high-quality data from multiple

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hospitals nationwide. However, there are significant limitations to this study. First, our study is retrospective. Inaccurate coding with ICD-9 code for diagnosis or CPT code for surgery can result in cases erroneously added in or omitted from the database. Furthermore, in our study, results regarding laterality and extent of surgery are extrapolated from CPT code and highly susceptible to this type of error. Definitions of certain variables, such as preoperative acute renal failure and postoperative acute kidney injury, differ from other consensus definitions and have been shown to underestimate the actual incidence and risk associated with each condition.[18] In addition, many clinical variables used in the assessment of ischemic colitis are not captured. These include variables such as physical exam findings, recent cardiac or vascular surgical history,[9 19–22] atrial fibrillation,[4 9 11] radiographic findings, colonoscopy results, evidence of gastrointestinal bleeding, hemorrhagic or hypovolemic shock, lactate levels[4 9 11 13] and the duration and severity of vasopressor use.[6 8 9] These clinically relevant factors should be studied further with large sample populations.

CONCLUSIONS

Independent risk factors of mortality after emergent colectomy for ischemic colitis include elderly age, poor functional status, multiple comorbidities, preoperative septic shock, preoperative blood transfusions, preoperative acute renal failure and delay from hospital admission to surgery. Identification of these risk factors may aid surgeons in patient selection for surgery, and making informed decisions with key stakeholders. Although it can be challenging to make an early diagnosis in ischemic colitis, prompt surgical intervention may improve outcomes.

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Competing interests None declared.

Ethics approval According to our institution's Office of Research Compliance and Quality Improvement, while the activity described in our study proposal involves research, it does not meet the definition of 'human subject research' as defined in the DHHS (45 CFR 46) or FDA regulations (21 CFR 50) for the protection of human subjects. The use of materials in our study proposal meets the definition of 'acceptably derived'.

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Data sharing statement The data from this study were obtained from the ACS-NSQIP Participant-use Files, and are available after agreeing to comply with the Data-use Agreement at the following website: https://www.facs.org/quality-programs/acs-nsqip/program-specifics/participant-use

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