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RESEARCH

Emergent Surgical Resection for Acute Mesenteric Ischemia: An ACS-NSQIP Analysis from 2005 to 2013.

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CONFLICTS OF INTEREST
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ABSTRACT:

Introduction

Acute mesenteric ischemia is a surgical emergency with a historical thirty-day mortality of 30%. We analyzed the largest set of ACS-NSQIP data in the literature to identify perioperative variables that affect mortality for acute mesenteric ischemia.

Methods

We utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to study demographic and perioperative variables that may be associated with morbidity and mortality after emergent surgical management of acute mesenteric ischemia. ACS-NSQIP participant user files (PUF) from 2005 to 2013 were queried for emergent cases of enterectomies, colectomies or both procedures at the initial operation with a postoperative diagnosis of vascular insufficiency of the intestine. Univariate correlations with mortality were analyzed. A multivariate logistic regression model was also developed using significant univariate correlations and controlling for age, gender and race.

Results

5237 cases met the inclusion criteria and constituted the analysis group. Overall mortality rate was 28.7%. There were 1978 cases of isolated enterectomies, 2949 cases of isolated colectomies and 310 cases of combined resections. Mortality rates were 24.2%, 29.4% and 50.6% respectively. Pre-operative variables most significantly associated with mortality were ventilator dependence (OR 4.76, 95% CI 4.14-5.46), sepsis (OR 3.37, 95% CI 2.85-3.99), renal failure (OR 2.59, 95% CI 2.16-3.11), blood transfusion (OR 2.39, 95% CI 1.94 – 2.95) and time to OR from hospital admission greater than one day (OR 1.91, 95% CI 1.68-2.17). Post-operative outcomes most significantly associated with death were comatose state (OR 14.73, 95% CI 6.94-31.29), cardiac arrest (OR 13.2, 95% CI 9.63-18.10), renal failure (OR 3.9, 95% CI 3.13-4.86), septic shock (OR 3.24, 95% CI 2.80-3.75), combined small and large intestinal resection (OR 2.74, 95% CI 2.17-

3.45) and blood transfusion (OR 2.07, 95% CI 1.71-2.5). In a multivariate logistic regression model the most likely contributors to death were postoperative comatose state (OR 11.14, 95% CI 4.11-30.16), preoperative ventilator dependence (OR 3.39, 95% CI 2.82-4.09) and postoperative septic shock (OR 3.17, 95% CI 2.63-3.82). A combined small and large intestinal resection also doubled mortality in this model (OR 2.06, 95% CI 1.54-2.76). Age over 60 years (OR 1.65, 95% CI 1.38-1.97) and white race (OR 1.26, 95% CI 1.01-1.57) were also significant for mortality.

Conclusion

Our analysis suggests an increased risk of death with a combined small intestinal and colonic resection for acute mesenteric ischemia. Comorbidities, postoperative complications and timing of surgical intervention all contribute significantly to the persistent high mortality rate in the emergent surgical management of acute mesenteric ischemia. Our results emphasize the continued need for early operation, aggressive resuscitation, limiting blood loss and need to transfusion and controlling perioperative infectious events. Earlier diagnostic methodologies need to be employed to intervene sooner and limit its morbidity and mortality.

KEYWORDS:

ACS-NSQIP, mesenteric ischemia, acute mesenteric ischemia, intestinal mesenteric ischemia, colonic mesenteric ischemia, ischemic colitis.

INTRODUCTION

Acute Mesenteric Ischemia (AMI) is a surgical emergency. Despite our best efforts, AMI carries a high rate of morbidity and mortality. A 2001 single institution study noted a 52% versus a historical 25% survival rate[1]. A 2006 report on AMI demonstrated in multivariate analysis that previous cardiac illness, acute renal failure, and large bowel ischemia had significant negative implications on patient survival. Intestinal resection was a favorable predictor of survival in this study[2]. Kougias et al in 2006 demonstrated a 30-day morbidity and mortality rate of 39% and 31%, respectively. Significant variables associated with mortality included age over 70 years, metabolic acidosis and bowel resection at the second-look operation[3]. In 2011, the first study utilizing the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) data from 2007 to 2008 noted thirty-day post-operative morbidity and mortality rates of 56.6% and 27.9% respectively. Recent MI, COPD and renal failure were all associated with post-operative morbidities while malnutrition, perforation and poor functional status were all associated with post-operative mortality[4]. A 2012 analysis by Alhan et al revealed a hospital mortality rate of 55.1%. Diabetes, digoxin and antiplatelet therapy, prolonged symptom duration, shock, acidosis, and re-laparotomy were all negative predictors of mortality[5].

ACS-NSQIP is the first nationally validated, risk-adjusted, outcomes-based program to measure and improve the quality of surgical care. It is designed to assist surgeons to improve surgical care through the use of risk-adjusted clinical data. There are currently over 600 hospitals participating in ACS-NSQIP with all data being collected by trained Surgical Clinical Reviewers (SCR). SCR's extract almost 200 demographic and perioperative variables retrospectively to include demographics, comorbidities, operations, and 30-day morbidity and mortality data. The annual de-identified participant user files (PUF's) compile this risk- and case-mix-adjusted data from 600 participating hospitals[6]. Our analysis utilized the PUF's from 2005 to 2013 to evaluate demographic and perioperative variables that

may be associated with morbidity and mortality following emergent surgical management of AMI. Our results were then compared to prior studies.

METHODS

Following Institutional Review Board exemption, we queried the adult ACS-NSQIP database participant user files (PUF) from 2005 to 2013 to examine the outcomes of emergent surgical management of acute mesenteric ischemia. We extracted only those cases with a postoperative diagnosis of vascular insufficiency of the intestines (ICD-9 codes 557.0x, 557.1x and 557.9x) and further narrowed our study population to only emergent operations on the small intestine, large intestine or both as the initial procedure. Table 1 lists the variables analyzed from the combined 9 years of PUF's. Descriptive statistics including frequencies, means and medians were extracted for individual variables and compared between survivors and non-survivors using student's t-test and Pearson's χ^2 test. Univariate correlations were analyzed with mortality using relative risk and odds ratios. A multivariate logistic regression model was developed with odds ratios for factors predicting mortality while controlling for age, gender and race. A p-value less than 0.05 was considered significant for all tests. SPSS for Windows v.23 (IBM, Chicago, IL) was used to analyze the data. The analyses used pairwise exclusion of missing data.

RESULTS

From 2005 to 2013 the ACS-NSQIP database recorded 5237 patients that required an emergent operation with a post-operative diagnosis of vascular insufficiency of intestines involving either the small or large intestine or both as principle procedure. This constituted our study population. Females constituted 57.2% (2998) of the population and males 42.7% (2236) while three patients' genders were not specified (0.1%). The mean age of the study population was 67.5 years and the median age was 70 years. The 30-day mortality rate for our study population was 28.7% (1503). Table 2 compares non-survivors and survivors based on demographics, ASA (American Society of Anesthesiologists Physical Status) classification, days from admission to surgery and operative time (initial procedure). Non-survivors were older, had a higher ASA classification of disease severity and were taken to surgery later than survivors. There were also three pregnant patients out of 3000 cases with complete data (0.1%) in the study population, none of whom died.

Preoperative Analysis

Table 3 lists the most significant preoperative variables and comorbidities associated with mortality. The highest odds of mortality were associated with CNS tumor (8.5, 95% CI 1.76-41.0), a comatose state defined as a patient who is unconscious or unresponsive to stimuli for at least 24 hours prior to the operation (6.03, 95% CI 3.22-11.29) and ventilator dependence (4.76, 95% CI 4.14-5.46). Age over 60 years incurred a 1.66 odds of death (95% CI 1.43-1.92). Other comorbidities significantly associated with mortality could be grouped by condition. Acute renal failure (OR 2.59, 95% CI 2.16-3.11) and requiring dialysis (OR 2.16, 95% CI 1.82-2.57) were significant risk factors for mortality. Malnutrition, quantified by an albumin < 2 g/dL (OR 2.51, 95% CI 2.11-2.98) and greater than 10% weight loss (OR 1.86, 95% CI 1.46-2.37) was also a significant predictor of mortality. Ascites within 30 days preoperatively (OR 1.54, 95% CI 1.26-1.88) was also significant. Significant cardiovascular and pulmonary risk factors for death included a history of peripheral vascular disease resulting in rest pain or gangrene (OR 3.77, 95% CI 1.96-7.25), CHF (OR 2.35, 95% CI 1.91-2.90), myocardial infarction within 30 days preoperatively (OR 2.35, 95% CI 1.80-3.07), chronic obstructive pulmonary disease (COPD) (OR 1.63, 95% CI 1.40-1.88), a history of cardiac surgery (OR 1.58, 95% CI 1.32-1.89), hypertension treated with medications (OR 1.29, 95% CI 1.13-1.49) and previous cardiac catheterization (OR 1.27, 95% CI 1.03-1.57). Blood transfusions given preoperatively (OR 2.39, 95% CI 1.94-2.95) and a history of a bleeding disorder (OR 1.56, 95% CI 1.37-1.78), which included acquired or iatrogenic coagulopathy, constituted significant hematologic risk factors for death. Infectious or immunologic risk factors included SIRS or sepsis preoperatively (OR 3.37, 95% CI 2.85-3.99), radiotherapy within 90 days preoperatively (OR 2.61, 95% CI 1.26-5.43), current pneumonia (OR 2.42, 95% CI 1.84-3.18), open wound infection (OR 2.33, 95% CI 1.91-2.83),

disseminated cancer defined as metastatic disease that is widespread, fulminant or near terminal (OR 1.94, 95% CI 1.39-2.72), and steroid use within 30 days preoperatively (OR 1.65, 95% CI 1.35-2.01).

Table 1. Database variables included in our analysis.

Demographics	Comorbidities	Procedure	Complications
Age	Diabetes	Principle	Death
Gender	Dyspnea	Other procedure 1	Surgical Site Infections
Race	Ventilator Dependence	Other procedure 2	Dehiscence
Body Mass Index (Height & Weight)	Chronic Obstructive Pulmonary Disease	Blood transfusions	Pneumonia
Alcohol use	Concurrent Pneumonia	Operative time	Unplanned intubations
Tobacco use	Ascites		Mechanical ventilation > 48 hours
	Esophageal varices		Renal insufficiency
	Renal failure		Renal failure
	Dialysis		Urinary Tract Infection
	Impaired sensorium		Cerebrovascular Accident
	Comatose > 24h		Comatose > 24h
	Hemiplegia		Cardiac arrest
	Transient Ischemic Attack or Cerebrovascular Accident		Myocardial infraction
	Central Nervous System tumors		Bleeding requiring blood transfusion
	Para or quadriplegia		Deep Venous Thrombosis / Phlebitis
	Disseminated cancer		Return to the Operating Room.
	Existing open wound infection		
	Chronic steroid use		
	Weight loss > 10%		
	Bleeding disorder or anticoagulation		
	Preoperative blood transfusion		
	Chemotherapy or Radiotherapy		
	Sepsis or septic shock		
	Prior operation w/in 30d		
	Days from hospital admission to OR		
	Preoperative WBC		
	Albumin		

Table 2. Preoperative demographics between non-survivors and survivors.

Factor	Non-survivors	Survivors	p-value
Age	70.16	66.49	< 0.01[a]
Female	57%	57%	NS[b]
White Race	84.6%	85%	NS[b]
Total Operative Time	109.97	112.83	NS[a]
American Society of Anesthesiologists Physical Status (ASA) Classification	4.08	3.46	< 0.01[a]
Body Mass Index	27.66	28.18	0.044[a]
Days from Hospital to Operating Room	4.25	2	< 0.01[a]
a - t-test p-value			
b - χ^2 p-value			

Table 3. Univariate analysis of preoperative variables vs. death.

Variable	OR of DEATH	95% CI
CNS Tumor	8.5	1.76-41.0
Coma > 24h	6.03	3.22-11.29
Ventilator Dependence	4.76	4.14-5.46
Rest pain / gangrene (Peripheral Vascular Disease)	3.77	1.96-7.25
Systemic Inflammatory Response Syndrome or Sepsis	3.37	2.85-3.99
Radiotherapy < 90d	2.61	1.26-5.43
Acute Renal Failure	2.59	2.16-3.11
Albumin < 2 g/dL	2.51	2.11-2.98
Impaired Sensorium	2.43	2.00-2.94
Current Pneumonia	2.42	1.84-3.18
Blood Transfusion < 72h	2.39	1.94-2.95
Congestive Heart Failure < 30d	2.35	1.91-2.90
Myocardial Infarction < 6 mos	2.35	1.80-3.07
Open wound infection	2.33	1.91-2.83
Dialysis	2.16	1.82-2.57
Prior Surgery < 30d	1.96	1.62-2.36
Disseminated Cancer	1.94	1.39-2.72
Time to Surgery > 1d	1.91	1.68-2.17
Weight Loss > 10%	1.86	1.46-2.37
Age > 60 years	1.66	1.43-1.92
Steroids < 30d	1.65	1.35-2.01
Chronic Obstructive Pulmonary Disease (COPD)	1.63	1.40-1.88
Cardiac Surgery	1.58	1.32-1.89
Bleeding Disorder	1.56	1.37-1.78
Ascites < 30d	1.54	1.26-1.88
Hypertension treated with medications	1.29	1.13-1.49
Cardiac Catheterization	1.27	1.03-1.57

Intraoperative Analysis

Table 4 lists the most significant intraoperative events associated with mortality. We grouped the primary operations performed into three categories; small intestinal resection only (SMALL) at 1978 (37.8%) operations, large intestinal resection only (LARGE) at 2949 (56.3%) operations and combined small and large intestinal resections (BOTH) at 310 (5.9%) operations. The mortality rates for SMALL, LARGE and BOTH operations were 24.2% (478), 29.4% (866) and 50.7% (157), respectively. Twenty-two percent of patients returned to surgery (n = 1154) after their initial operation. Patients who underwent both a small and large intestinal resection for AMI during the initial operation had an increased risk of death (n = 310, OR 2.74, 95% CI 2.17-3.45) while an isolated small intestinal resection decreased the risk of death (OR 0.7, 95% CI 0.61-0.79). Isolated colectomy was not associated with mortality (n = 2949, OR 1.08, 95% CI 0.96-1.22). Receiving blood transfusions in the operating room (n = 691, OR 2.07, 95% CI 1.71-2.50) conferred an increased risk of death.

Postoperative Analysis

Table 4 also lists the most significant postoperative variables associated with mortality. Mechanical ventilation for over 48 hours (37.84%, n = 1984), requiring blood transfusions intraoperatively (31.24%, n = 691) or postoperatively (24.75%, n = 1296) and septic shock (17.95%, n = 940) were the most common complications. While cardiac arrest conferred an expected high risk of death (n = 273, OR 13.2, 95% CI 9.63-18.10), comatose state for more than 24 hours (n = 54, OR 14.73, 95% CI 6.94-31.29), renal failure (n = 356, OR 3.9, 95% CI 3.13-4.86) and septic shock (n = 940, OR 3.24, 95% CI 2.80-3.75) also contributed significantly to mortality. Cerebrovascular accidents with (n = 109, OR 2.41, 95% CI 1.64-3.52) and without residual deficits (n = 209, OR 1.64, 95% CI 1.23-2.19), mechanical ventilation for more than 48 hours (n = 1984, OR 1.95, 95% CI 1.72-2.20) and myocardial infarction (n = 141, OR 1.94, 95% CI 1.38-2.72) were associated with mortality. Postoperative blood transfusion (n = 1296, OR 2. 07, 95% CI 1.82-2.36) conferred an increased risk of death. Returning to surgery (n = 1154, OR 1.43, 95% CI 1.24-1.64) and a postoperative pneumonia (n = 757, OR 1.3, 95% CI 1.10-1.53) increased the risk of death. Variables that statistically decreased the risk of death included sepsis without shock (n = 534, OR 0.77, 95% CI 0.63-0.95), organ space surgical site infections (n = 290, OR 0.75, 95% CI 0.57-0.99), urinary tract infections (n = 291, OR 0.62, 95% CI 0.61-0.80) and wound dehiscence (n = 150, OR 0.49, 95% CI 0.61-0.81).

Combined Multivariate Logistic Regression Model for Mortality

A multivariate logistic regression model for mortality was developed using the significant variables from the univariate analyses while controlling for age, gender and race as cofactors (table 7). The Pearson Goodness-of-Fit χ^2 was 1881.30 for this model ($p < 0.01$) with accuracies in predicting survivors and non-survivors at 90.6% and 42.3%, respectively yielding an overall accuracy of this model of 76.3%. Postoperative cardiac arrest was excluded from this model.

Postoperative comatose state for more than 24 hours was the highest predictor of mortality (OR 11.14, 95% CI 4.11-30.16). Postoperative septic shock (OR 3.17, 95% CI 2.63-3.82), myocardial infarction (OR 2.38, 95% CI 1.55-3.67) as well as combined small and large intestinal resection (OR 2.06, 95% CI 1.54-2.76) were additional factors contributing to mortality. Preoperatively ventilator-dependence multiplied the risk of death by 3.39 (95% CI 2.82-4.09) while preoperative SIRS or sepsis increased mortality risk by 1.84 (95% CI 1.50-2.27). Preoperative weight loss greater than 10% (OR 1.77, 95% CI 1.31-2.39), disseminated cancer (OR 1.68, 95% CI 1.07-2.63) and age over 60 years (OR 1.65, 95% CI 1.38-1.97) were the comorbidities associated with death. Preexisting renal disease also contributed to mortality as reflected in a dialysis requirement (OR 1.54, 95% CI 1.23-1.92) and renal failure (OR 1.39, 95% CI 1.10-1.76). Steroid use increased the risk of death by 1.5 times (95% CI 1.17-1.93). Malnutrition defined by a preoperative albumin less than 2 g/dL (OR 1.30, 95% CI 1.05-1.62) in addition to the risk from weight loss was highly predictive of death. While not significant in our univariate analysis, white race resulted in an increased mortality risk (OR 1.26, 95% CI 1.008-1.57). Postoperative bleeding requiring blood transfusions

increased the risk of death (OR 1.34, 95% CI 1.13-1.59). A delay to surgery from admission more than 24 hours was also significant in this model for mortality (OR 1.22, 95% CI 1.03-1.45). Statistically decreasing the risk of death in this model were organ space surgical site infection (OR 0.52, 95% CI 0.37-0.75), urinary tract infection (OR 0.49, 95% CI 0.34-0.70) and wound dehiscence (OR 0.46, 95% CI 0.27-0.78).

Table 4. Univariate analysis of operative and postoperative variables vs. death.

Variable	Frequency & (N)	OR of DEATH	95% CI
Coma for > 24h	1.03% (54)	14.73	6.94-31.29
Cardiac Arrest	5.21% (273)	13.2	9.63-18.10
Renal Failure	6.80% (356)	3.9	3.13-4.86
Septic Shock	17.95% (940)	3.24	2.80-3.75
BOTH Operations	5.92% (310)	2.74	2.17-3.45
Cerebrovascular Accidents w/ deficits	2.08% (109)	2.41	1.64-3.52
Intraoperative blood transfusion	31.24% (691)[a]	2.07	1.71-2.50
Bleeding requiring transfusions	24.75% (1296)	2.07	1.82-2.36
Mechanical ventilation > 48h	37.84% (1984)	1.95	1.72-2.20
Myocardial infarction	2.69% (141)	1.94	1.38-2.72
Reintubation	11.32% (593)	1.7	1.42-2.02
Cerebrovascular Accident w/o deficits	6.04% (209)[b]	1.64	1.23-2.19
Return to Surgery	22.04% (1154)	1.43	1.24-1.64
Pneumonia	14.45% (757)	1.3	1.10-1.53
Sepsis	10.20% (534)	0.77	0.63-0.95
Organ Space Surgical Site Infections	5.54% (290)	0.75	0.57-0.99
SMALL Operations	37.77% (1978)	0.7	0.61-0.79
Urinary Tract Infection	5.56% (291)	0.62	0.61-0.80
Dehiscence	2.86% (150)	0.49	0.61-0.81

a - Out of 2212 cases with 3025 cases missing data
b - Out of 3459 cases with 1778 cases missing data

Table 5. Multivariate analysis of demographic and perioperative variables vs. death.

Variable	OR	95% CI Lower	95% CI Upper	p-value
Postop Coma > 24h	11.14	4.11	30.16	.000
Preop Ventilator Dependence	3.3	2.82	4.09	.000
Postop Septic Shock	3.170	2.63	3.82	.000
Postop Myocardial Infarction	2.38	1.55	3.67	.000
Postop Renal Failure	2.29	1.72	3.06	.000
BOTH Operations	2.06	1.54	2.76	.000
Preop Systemic Inflammatory Response Syndrome or Sepsis	1.84	1.50	2.27	.000
Preop Weight Loss > 10%	1.77	1.31	2.39	.000

Disseminated Cancer	1.68	1.07	2.63	.023
Age > 60 years	1.65	1.38	1.97	.000
Preop Dialysis	1.54	1.23	1.92	.000
Preop Steroid use	1.50	1.17	1.93	.002
Preop Renal Failure	1.39	1.10	1.76	.006
Postop Bleeding requiring transfusions	1.34	1.13	1.59	.001
Preop Albumin < 2 g/dL	1.30	1.05	1.62	.017
White Race	1.26	1.01	1.57	.042
Time to Surgery > 1 day	1.22	1.03	1.45	.019
Female Gender	1.08	0.92	1.26	.360
Postop Organ Space Surgical Site Infection	0.52	0.37	0.75	.000
Postop Urinary Tract Infection	0.49	0.34	0.70	.000
Postop Dehiscence	0.46	0.27	0.78	.004

DISCUSSION

Our analysis of the ACS-NSQIP data on the outcomes of emergent operation for AMI indicated the disease process continues to carry a high risk of mortality. Notably, we found that the type of operation required significantly affects mortality at different rates with a combined small and large intestinal resection having twice the risk of death as an isolated operation on either the small or large bowel. While one cannot control preoperative comorbidities in emergent operations, earlier operative intervention in this patient cohort has a significant effect on mortality according to our results.

Moreover, some of the postoperative complications which figure prominently in the multivariate analysis may be mitigated not only by early surgical intervention but with aggressive and timely resuscitation in a monitored ICU setting. Our analysis also suggests that earlier surgical intervention portends a lower risk of death.

Historically, mesenteric ischemia portends a poor prognosis with mortality rates reported as high as 70 to 80%[7–9]. Our overall mortality rate of 28.7% clearly reflects an evolution of the medical and surgical management of this disease yet is still higher than other emergency surgical diseases. Older age and a higher ASA classification predict a higher risk of mortality. ASA classification while subjective, is a surrogate for severity of disease at presentation that incorporates patient clinical status and comorbidities. Perhaps alternative classification models such as the SOFA (Sepsis-related Organ Failure Assessment) and APACHE (Acute Physiology and Chronic Health Evaluation) scores would yield more precise information. To control for this, we examined a multitude of preoperative comorbidities to further characterize specific contributors to mortality. Preoperative ventilator dependence and SIRS are factors which are both predictive of mortality risk, and included in development of the subjective ASA classification, lending validation for ASA relationship to mortality risk and inclusion in this study.

A single retrospective analysis performed in Sweden analyzed patients diagnosed with AMI either at autopsy or operation between 1970 and 1982. The overall incidence rate of acute mesenteric ischemia was 12.9/100,000 person-years. The incidence of acute superior mesenteric artery occlusion, mesenteric venous thrombosis, and non-occlusive mesenteric ischemia (NOMI) were approximately 68%, 16%, and 16% respectively. In-hospital mortality was highest for NOMI, lower for acute superior mesenteric artery occlusion, and lowest for mesenteric venous thrombosis[10]. With improvements in intensive care and nutritional support, as well as increased use of revascularization procedures, the decrease in mortality was marginal[11]. Progress in improving survival came with the implementation of combined surgical approach and second-look operations for on-going ischemia when compared to primary

resection and closure. This resulted in 24% mortality rate in those treated with the combined approach and an overall mortality rate of 40%[12].

While gender was not a significant mortality risk factor in our univariate analysis, it did achieve significance as the control in the multivariate model. Race was found to be significant in our multivariate model with an increased risk of mortality for whites. A 2013 ACS-NSQIP analysis by Causey et al analyzed the impact of race on outcomes following emergency surgery. Evaluating 75,280 patients over a 4-year time span undergoing emergency abdominal surgery, they demonstrated a 1.25-fold increase in complications for blacks but no difference in mortality compared to whites. When combining all minority groups in comparison with the white cohort, overall complications were only slightly increased for minorities though mortality was reduced by 1.7-fold[13]. More investigative analysis of the increased rate of mortality in Caucasians in relation to minority groups presenting with surgical emergencies is needed.

In our analysis, a combined small and large intestinal resection doubled the risk of death when compared to isolated resections. This has been suggested previously by Aliosmanoglu et al who observed a significant difference in mortality rates between those suffering intestinal necrosis and those that had combined intestinal and colonic involvement[14]. Other authors have demonstrated similar findings with small and large bowel involvement identified as risk factors for perioperative mortality[2]. Whether the increase in mortality is related to more advanced disease due to delayed diagnosis or because of a more diffuse process of the inciting event is unknown. The first series to report prognostic factors in 1995 demonstrated that survivors were operated on within 12 hours of presentation, had a normal chest radiograph and a higher arterial oxygen tension. Non-surviving patients had extensive bowel infarction involving both small and large intestine ($p < 0.05$)[15] which is consistent with our findings. Depending on the classification of ischemia and treatment procedure, mortality ranges from 17.7% to 47% with rates increasing in those that underwent bowel resection[16]. Mortality has been shown to be higher in those that have colonic ischemia in the setting of intestinal necrosis[14]. While this may reflect a synchronous disease process, our analysis did not demonstrate an increased risk of mortality with isolated colonic resection. Laboratory values implicated in worse prognosis include elevated L-lactate and positive D-dimer and profound leukocytosis[17]. Leukocytosis was not found to be associated with mortality in our analysis. A 2015 retrospective, observational, non-interventional study of 780 patients with AMI diagnosed either on CT scan, endoscopy, or upon surgical exploration demonstrated risk factors for death in ICU patients[18]. Older age, multi-system organ failure, and plasma lactate concentration greater than 2.7 mmol/L at initial diagnosis were independent risk factors of mortality. A 4-year review of AMI published in 2015 demonstrated a 30-day mortality rate of 66%. On logistical regression analysis, independent predictors of mortality were small bowel necrosis of more than 100 cm and a serum creatinine level greater than 2 mg/dL[19]. Our analysis could not comment on the extent of intestinal resection other than small or large intestine or both. Presumably outcomes have not improved significantly over time because of delays in diagnosis and an increasing incidence of comorbidities in this patient population[17,20].

LIMITATIONS

Strengths of this study include the large sample size and the integrity of data that is required for participation in ACS-NSQIP. Some weaknesses include the evolution of ACS-NSQIP which has added variables over the course of our PUF extraction period so not all factors could be analyzed for the full period of our investigation and thus were not included in the analysis. More granular data, perhaps in a procedure targeted database, may yield a better predictive model for mortality. Given the large sample size our analysis is also at risk for type I errors. There were also very few cases recorded of revascularization and our analysis excluded second and third procedures performed; i.e. second-look or return to the OR.

CONCLUSION

Our analysis suggests an increased risk of death with a combined small intestinal and colonic resection for

acute mesenteric ischemia. This may reflect the extent, severity and progression of disease on initial presentation. Comorbidities, postoperative complications and the timing of surgical intervention all contribute significantly to outcomes in the emergent surgical management of acute mesenteric ischemia. Our results emphasize the need for early operation, aggressive resuscitation, limiting blood loss and need to transfusion and controlling perioperative infectious events.

The American College of Surgeons National Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein: they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors. This study does not represent the views or plans of the ACS or the ACS-NSQIP.

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