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ORIGINAL ARTICLE

A 10-Year Longitudinal Analysis of Surgical Management for Acute Ischemic Colitis

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Abstract
Introduction Our objective was to review our 10-year experience of surgical resection for acute ischemic colitis (IC) and to assess the predictive value of previously reported risk-stratification methods.
Methods We retrospectively reviewed all adult patients at our institution undergoing colectomy for acute IC between 2000 and 2009. Descriptive statistics were calculated. Long-term survival was assessed using Kaplan–Meier methods and in-hospital mortality using multivariate logistic regression. Patients were risk-stratified based on previously reported methods, and discriminatory accuracy of predicting in-hospital mortality was evaluated by the area under the curve (AUC) of the receiver operating characteristic (ROC) curve.
Results A total of 115 patients were included for analysis, of which 37 % (n=43) died in-hospital. The median survival was 4.9 months for all patients and 43.6 months for patients surviving to discharge. Seventeen patients subsequently underwent end-ostomy reversal at our institution, with in-hospital mortality of 18 % (n=3) and ICU admission for 35 % (n=6). The discriminatory accuracy of risk stratification in predicting in-hospital mortality based on ROC AUC was 0.75.
Conclusion Acute IC continues to remain a very deadly disease. Patients who survive the initial acute IC insult can achieve long-term survival; however, we experienced high rates of death and complications following elective end-ostomy reversal. Risk stratification provides reasonable accuracy in predicting postoperative mortality.

Keywords Ischemic colitis · Colonic diseases/surgery · Postoperative period · Postoperative complications · Outcomes assessment

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Introduction

Fulminant acute ischemic colitis (IC) remains one of the most severe abdominal emergencies with mortality rates for gangrenous or total colonic ischemia reported to be as high as 75 % after surgical intervention.[1–8] Acute IC has been reported to occur in 4.5 to 44 cases per 100,000 person-years in the general population, and the incidence is expected to increase given the growing proportion of elderly patients.[8–12]

Knowledge of predictive factors for morbidity and mortality following total or partial colectomy for IC is limited. Reports of risk factors and outcomes for the full spectrum of this disease process include only a small subset of patients undergoing surgical resection, with little information specific to this cohort.[2,7,8,11–18] Previous studies focusing on surgical intervention for IC (including revascularization) have been ill-equipped to provide a meaningful analysis of factors contributing to postoperative mortality as they generally report too few patients undergoing abdominal exploration.[1,5,19–23] Given the relative infrequency of this condition,[6,9,16] case series with 100 or more patients undergoing surgical resection for acute IC are exceedingly rare.[24,25]

In the current study, we present the largest case series of patients requiring total or partial colectomy for acute IC reported in the USA to date. The primary objectives of this study are twofold: (1) to review our 10-year experience of surgical resection for acute IC at a tertiary care center and (2) to assess previously reported risk-stratification methods to predict mortality.[25] As a subanalysis, we assess the long-term outcomes of patients who survived the initial IC event and went on to later undergo end-ostomy reversal at our institution.

Materials and Methods

Ethics

This study was approved by the Institutional Review Board of Duke University Medical Center.

Data Source

Our institution maintains an enterprise data warehouse that allows investigators access to administrative, financial, and clinical information generated during patient care.[26] This system was used for this study to acquire patient demographic information, pre-existing comorbidities at the time of surgery, operative characteristics, postoperative complications, and survival information. These data were supplemented, validated, and cross-referenced with manual chart review. Survival data were cross-referenced with the Social Security Death Index and tumor registries, which provided for a more complete and validated survival follow-up in the event that a patient may have relocated or otherwise been lost to our center's follow-up.

Study Design

We identified all patients at our institution undergoing total or partial colectomy for acute ischemic colitis during the 10-year period of 01/01/2000 through 12/31/2009 using the following process: (1) the data warehouse was queried for all patients age 18 or older with diagnosis of vascular insufficiency of the intestine [International Classification of Disease, Ninth Revision (ICD-9) codes 569.90, 557, 557.0, 557.1, and 557.9] and who also underwent a surgical procedure involving the colon [Current Procedure Terminology (CPT) codes 44140, 44141, 44143–44146, 44155–44158, 44160, 44202, 44204–44208, 44210, and 44211; ICD-9 procedure codes 17.3–17.36, 17.39, 45, 45.03, 45.41, 45.7–45.76, 45.79, 45.8–45.83, 46.04, 47.20, 47.5, 47.50, and 47.6]. (2) This list was then manually reviewed by examination of the medical record to identify patients who underwent partial or total colon resection for acute IC. This determination was based on clinical notes, operative reports, radiographic images, and pathology reports. Patients undergoing surgery for chronic colonic ischemia or colonic ischemia secondary to volvulus, herniation, or trauma were excluded.

For the resulting population of patients undergoing surgical resection for acute IC, data was captured related to patient demographics [gender, age, race, and body mass index (BMI)], pre-existing comorbidities (diabetes, pulmonary disease, cardiovascular disease, and peripheral vascular disease), nutritional status at the time of surgery (based on preoperative albumin level), operative characteristics [American Society of Anesthesiologists (ASA) physical status classification, type of surgery (segmental colon resection, ileocecectomy, or subtotal/total colectomy), laterality (right, middle, left, multi-segment, total/subtotal), operative time, intraoperative blood product transfusion, and intraoperative vasoactive medication administration], postoperative metrics [hospital length of stay, intensive care unit (ICU) length of stay, and days requiring ventilator support], postoperative complications [infection, deep vein thrombosis, pulmonary embolism, acute renal failure (ARF), need for dialysis, stroke, atrial fibrillation, myocardial infarction, cardiopulmonary arrest, reoperation, tracheostomy placement, and need for surgical feeding tube placement], and survival information. For patients who received an end-ostomy intraoperatively and ultimately went on to receive ostomy reversal at our institution, a subanalysis was performed to evaluate perioperative outcomes following end-ostomy reversal (loop-ostomy takedowns were not included in this subanalysis).

Patients were stratified based on the Ischemic Colitis Mortality Risk (ICMR) Score.[25] This score ranges from 0 to 5 based on 1 point for each of the following factors: non-occlusive etiology, renal failure requiring dialysis postoperatively, subtotal colectomy, peak preoperative lactate >2.5 mmol/L, and pre- or intraoperative administration of catecholamines. Patients for whom it was deemed clinically unnecessary to measure serum lactate were considered as having a lactate <2.5 mmol/L. The method the authors used to determine non-occlusive etiology when developing the ICMR Score is not specifically delineated. We therefore defined this as the absence of documented thromboembolic disease with one of the following conditions preceding the onset of acute IC: (1) patients with profound hypovolemia and cardiogenic or hemorrhagic shock; (2) patients undergoing major cardiovascular surgery (aortic reconstruction, aortic aneurysm repair, coronary artery bypass graft, coronary valvular repair, or cardiac transplant); (3) myocardial infarction with hemodynamic compromise; or (4) documented decompensated heart failure.

Statistical Analysis

Preoperative, intraoperative, and postoperative variables were described with means (±standard deviation) for continuous variables and proportions (count, percent) for categorical variables. Overall survival was analyzed using Kaplan–Meier methodology. Additionally, multivariate logistic regression was performed to assess the association between patient/operative characteristics and in-hospital mortality, with covariates determined a priori based on previously reported variables demonstrated to impact postoperative mortality.[6,10] Patients were risk-stratified based on the ICMR Score, and the discriminatory accuracy of predicting in-hospital mortality was evaluated by the area under the curve (AUC) of the receiver operating characteristic (ROC) curve.[27] A probability value ≤0.05 was used to indicate statistical significance for all comparisons and analyses. All statistical analyses were performed using Stata version 11.0 (College Station, TX, USA) and JMP version 10.0 (SAS Institute Inc., Cary, NC, USA).

Results

A total of 115 patients undergoing partial or total colectomy for acute IC were included for analysis, and the distributions of the demographic and comorbid characteristics of the study population are shown in Table 1. Coronary artery disease and diabetes were the most common pre-existing conditions (30 % and 20 %, respectively). Fifty-nine patients (51 %) had hypoalbuminemia (<3.5 g/dL) at the time of surgery and the mean peak lactate level was 5.1 mmol/L (range 0.6–30 mmol/L). History of recent surgery was present in 53 (48 %) of patients with 30 patients (26 %) undergoing major cardiovascular surgery preceding the onset of IC.

Clinical findings consistent with a non-occlusive etiology of acute IC were present in 43 % (n=49) of patients in our study. The preponderance of clinical evidence suggests that the remaining 57 % of patients (n=66) had thromboembolic disease. Segmental colon resection was the most common procedure performed (n=61, 53 %) with right-sided location of disease predominant (n=56, 49 %) and 100 patients (87 %) receiving either an ileostomy or colostomy at the time of surgery (Table 2). Intraoperative anesthesia data was available for 108 patients. Of these, the mean operative time was 203±60 min with 61 patients (56 %) requiring intraoperative blood product transfusion and 53 patients (49 %) requiring adrenergic vasopressor infusion intraoperatively [29 of these (55 %) also required adrenergic vasopressor support preoperatively].

Table 1 Summary of patient demographics and comorbid conditions (n=115)

Age (years)	64±12
Male	64 (56 %)
BMI (n=87)	28.3±7.4
Race	
White	84 (73 %)
Black	25 (22 %)
Other	6 (5 %)
Diabetic	23 (20 %)
COPD	12 (10 %)
Coronary artery disease	34 (30 %)
Atrial fibrillation	20 (17 %)
ASA Classification ≥4	88 (77 %)
Hypoalbuminemia (<3.5 g/dL)	59 (51 %)
Peak lactate level (n=101) (mmol/L) [range]	5.1±5.1 [0.6–30]
History of recent surgery	
None	62 (54 %)
Cardiovascular	30 (26 %)
Gastrointestinal	14 (12 %)
Other	9 (8 %)

For continuous variables, the entries are means (±standard deviations). For categorical variables, the entries are number (percentage) of patients with the characteristic

Overall, the postoperative course of patients undergoing surgery for acute IC was associated with high rates of morbidity and mortality (Table 3). In total, 42 patients (37 %) met criteria for sepsis postoperatively with 17 (15 %) manifesting with fulminant septic shock. Non-infectious postoperative complications were also common with 33 patients (29 %) developing atrial fibrillation and 18 (16 %) suffering a postoperative myocardial infarction. A total of 22 patients (19 %) required hemodialysis postoperatively, of which seven (32 %) had previously received dialysis at our institution prior to the day of surgery. Moreover, 23 patients (20 %) required a second operation during their index hospitalization (excluding tracheostomy or feeding tube placement). Of the 23 patients undergoing reoperation, the most common reason for the second surgery was clinical deterioration precipitating re-exploration (n=10), of which the in-hospital mortality was 70 %. A total of 26 % (n=6) of the reoperations were a planned second exploration. Five of these six cases were situations where the patient was too unstable during the index operation to complete a definitive procedure. In only one case was the second operation planned solely for purposes of allowing better demarcation of viable bowel. In hospital mortality for the patients undergoing a planned second operation was 33 % (=2 of 6). Other reasons for a second operation included facial dehiscence (n=2) and wound complications (n=2). The mean length of stay was 26±22 days with 106 patients

Table 2 Summary of intraoperative patient characteristics

Type of resection	
Segmental colon resection	61 (53 %)
Ileocecectomy	12 (10 %)
Subtotal/total colectomy	30 (26 %)
Hartmann's	12 (10 %)
Location of ischemic disease	
Right	56 (49 %)
Left	25 (22 %)
Pancolonic	30 (26 %)
Multiple segmental	4 (3 %)
Ostomy	
Ileostomy	76 (66 %)
Colostomy	24 (21 %)
None	16 (14 %)
Operative time (min) (n=108)	203±60
Estimated blood loss (mL) (n=108)	340±581
Required blood product transfusion (n=108)	61 (56 %)
Adrenergic vasopressor requirement preoperatively (n=108)[a]	29 (27 %)
Adrenergic vasopressor requirement intraoperatively (n=108)	53 (49 %)

For continuous variables, the entries are means (±standard deviations). For dichotomous variables, the entries are number (percentage) of patients with the characteristic

[a] All patients requiring adrenergic vasopressors preoperatively also required these medications intraoperatively

Table 3 Summary of in-hospital postoperative outcomes

30-Day mortality	41 (36 %)
In-hospital mortality	43 (37 %)
Specific complications	
Urinary tract infection	16 (14 %)
Pneumonia	13 (11 %)
Sepsis	42 (37 %)
Septic shock	17 (15 %)
Other infection	29 (25 %)
Deep venous thrombosis	1 (1 %)
Pulmonary embolism	3 (3 %)
Acute renal failure[a]	13 (11 %)
Need for hemodialysis[b]	22 (19 %)
Stroke	2 (2 %)
New atrial fibrillation	33 (29 %)
Myocardial infarction	18 (16 %)
Cardiopulmonary arrest	12 (10 %)
Reoperation in same admission[c]	23 (20 %)
Placement of tracheostomy	12 (10 %)
Placement of feeding tube	24 (21 %)
ICU admission	106 (92 %)
Days in ICU (n=106)	12±16
Ventilator support required (past the day of surgery)	50 (43 %)
Average postoperative days on ventilator (n=50)	9±16
Total length of hospitalization (days)	26±22
Hospital readmission for surviving patients (n=72)	18 (25 %)

For continuous variables, the entries are means (±standard deviations). For dichotomous variables, the entries are number (percentage) of patients with the characteristic

[a] Acute renal failure is defined as a normal creatinine at the time of surgery and a creatinine ≥3 postoperatively

[b] Seven of the 22 patients had previously received dialysis at our institution prior to surgery

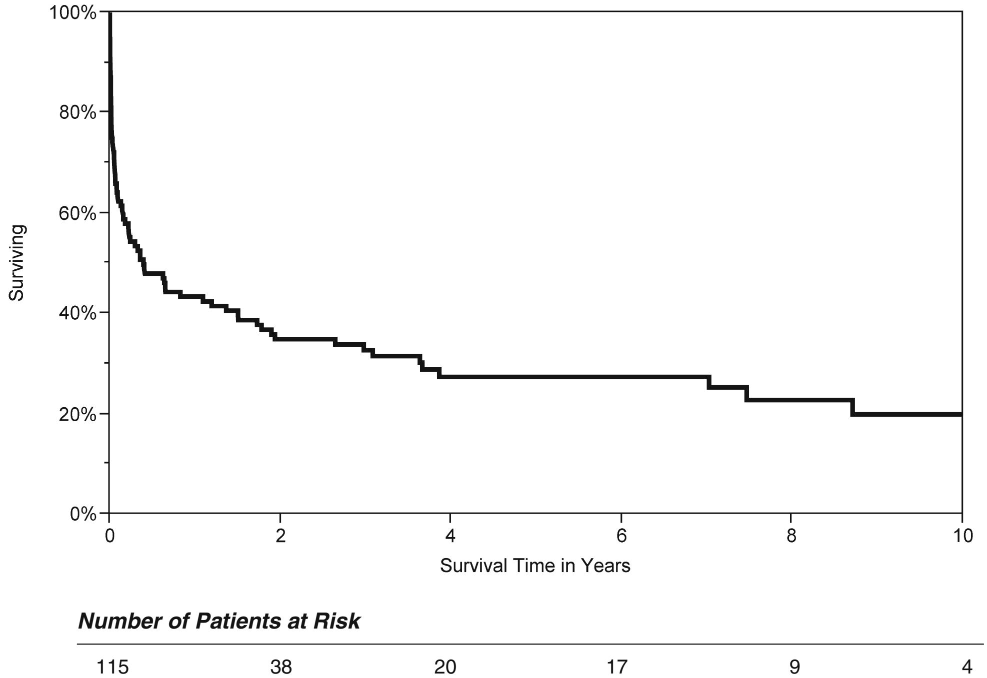
[c] Excludes tracheostomy or feeding tube placement

(92 %) requiring ICU admission for a mean length of 12±16 days, and 50 patients (43 %) requiring ventilator support beyond the day of surgery for a mean length of 9±16 days. The in-hospital mortality rate after surgery was substantial with 43 patients (37 %) dying during their index admission. Of the 72 patients who survived to discharge, 25 % (n=18) required readmission within 30 days. The most common reasons for readmission were dehydration due to high ostomy output (n=5) and intra-abdominal abscess (n=4). Other reasons for readmission included altered mental status (n=2) and wound complications (n=2).

Kaplan–Meier survival estimates at 1 year, 3 years, and 5 years were 43 %, 33 %, and 27 %, respectively (Fig. 1). The median survival for all patients with acute IC was 4.9 months [95 % confidence interval (CI) = 2.1–18.0], while the median long-term survival for patients surviving to discharge from their initial hospitalization was 43.6 months (95 % CI = 18.0–104). Factors associated with in-hospital mortality upon multivariate logistic regression analysis included ASA Class ≥4 [adjusted odds ratio (AOR) 6.91, 95 % CI = 2.17–30.98; p=0.0005], peak preoperative lactate level (AOR per unit increase = 1.26, 95 % CI = 1.11–1.47; p<0.0001), renal failure requiring postoperative hemodialysis regardless of preoperative dialysis requirement (AOR = 5.11, 95 % CI = 1.72–16.88; p=0.003), intraoperative adrenergic vasopressor use (AOR = 3.53, 95 % CI = 1.47–8.82, p=0.0047), and intraoperative blood loss ≥500 mL (AOR = 2.63, 95 % CI = 1.00–7.21; p=0.05) (Table 4). When compared to patients with occlusive disease, there was no significant association of non-occlusive disease with in-hospital mortality (AOR = 1.58, 95 % CI = 0.68–3.65; p = 0.2874).

Given the association between intraoperative blood loss and in-hospital mortality, we analyzed preoperative hemoglobin levels (mean = 11.0±2.1 g/dL for female gender and 11.5±2.4 g/dL for male gender). Anemia (defined as <12.0 g/dL for females and <13.7 g/dL for males) was also quantified (n=89). Preoperative hemoglobin level was not associated with in-hospital mortality upon multivariate logistic regression (AOR per g/dL increase = 1.01, 95 % CI = 0.77–1.32; p=0.9460 for females and AOR = 0.97, 95 % CI = 0.74–1.25; p=0.7922 for males). Additionally, there was no significant interaction

Fig. 1 Kaplan–Meier survival curve



between preoperative anemia and intraoperative blood loss >500 mL in predicting in-hospital mortality (p=0.4697).

Of the 72 patients who survived to discharge, 17 patients (24 %) ultimately went on to undergo elective end-ostomy reversal at our institution. The in-hospital mortality from this procedure was 18 % (n=3) with 35 % (n=6) requiring ICU admission and a mean hospital length of stay of 27± 25 days (Table 5). Of the three patients who died postoperatively, one patient died from complications of heart failure, one from infectious complications due to an anastomotic leak, and one due to overwhelming sepsis of unclear etiology (no evidence of anastomotic leak upon re-exploration).

Risk stratification based on the ICMR Score previously reported by Reissfelder et al.[25] resulted in discriminative accuracy in predicting in-hospital mortality based on the area under the curve of the receiver operating characteristics curve of 0.751 (Fig. 2). Individual components of the ICMR Score associated with in-hospital mortality included preoperative lactate > 2.5 mmol/L (p=0.0006), renal failure requiring hemodialysis postoperatively (p=0.003), and intraoperative adrenergic vasopressor use (p=0.0047), while non-occlusive etiology and total/subtotal colectomy are components of the ICMR Score that did not have a significant association with in-hospital mortality in our study population (p=0.29 and p=1.00, respectively) (Table 4).

A total of 14 patients (12 %) did not have laboratory data for lactate level at the time of surgery. All of these cases were from the first 3 years of the study (2000–2003) with the exception of one patient from 2004. The lactate component of the ICMR Score was calculated assuming that missing lactate levels were cases where it was deemed clinically unnecessary to obtain a lactate level. Given that the predominance of missing values in the early part of the study could represent difference in practice patterns in earlier years, the multivariate regression model evaluating the lactate component of the ICMR Score was re-run excluding these records, and preoperative lactate levels >2.5 mmol/L retained statistical significance (p=0.0079). Given the statistical significance of preoperative lactate levels, we performed recursive partitioning[28] to separate lactate levels into four ranges on the basis of maximal separation with respect to the rate of in-hospital mortality. The four ranges generated by this technique were <1.1 mmol/L (n=7, in-hospital mortality 0 %), 1.1–4.8 mmol/L (n=60, in-hospital mortality 27 %), 4.9–14.9 mmol/L (n=25, in-hospital mortality 68 %), and ≥15 mmol/L (n=9, in-hospital mortality 100 %).

Discussion

Perioperative and long-term outcomes for patients with acute ischemic colitis severe enough to require partial or total colectomy remain important concerns for general surgeons, patients, and their families. In the current study, we report the largest series in the USA evaluating postoperative morbidity and mortality in this patient population. In addition, this analysis provides further clinical guidance in predicting patients at high risk for postoperative death by evaluating the Ischemic Colitis Mortality Risk Score as a tool in predicting postoperative mortality.

Table 4 Multivariate logistic regression for association with in-hospital mortality

Variable	Adjusted odds ratio	95 % CI	*p* value
Age (AOR per year increase)	1.03	0.99–1.06	0.1108
ASA Class ≥4	6.91	2.17–30.98	0.0005*
Right-sided colonic ischemia	0.53	0.23–1.19	0.1236
Female gender	0.89	0.39–2.02	0.7710
BMI (AOR per unit increase)	1.01	0.94–1.09	0.7783
Diabetes	1.31	0.47–3.63	0.6014
COPD	1.32	0.36–4.82	0.6717
Congestive heart failure	1.26	0.43–3.75	0.6547
Coronary artery disease	1.26	0.52–3.07	0.6069
Preoperative atrial fibrillation	0.85	0.29–2.43	0.7610
Peripheral vascular disease	1.61	0.47–5.90	0.4622
Hypoalbuminemia <3.5 g/dL	1.73	0.76–4.03	0.1927
Peak preoperative lactate (mmol/L) (AOR per unit increase)	1.26	1.11–1.47	<0.0001*
Components of ICMR Score			
Preoperative lactate >2.5 mmol/L	4.82	1.95–12.79	0.0006*
Non-occlusive etiology	1.58	0.68–3.65	0.2874
Postoperative dialysis requirement	5.11	1.72–16.88	0.0030*
Total or Subtotal Colectomy	1.00	0.33–3.01	0.9977
Intraoperative Adrenergic Vasopressors	3.53	1.47–8.82	0.0047*
Adrenergic Vasopressors Preoperatively	2.07	0.81–5.42	0.1305
Preoperative Hemoglobin Level (AOR per unit increase)			
Female gender	1.01	0.77–1.32	0.9460
Male gender	0.97	0.74–1.25	0.7922
Total ICMR Score (AOR per unit increase)	2.11	1.44–3.22	<0.0001*
Major CV surgery preceding IC	0.89	0.33–2.28	0.8020
Operative time (min)			
AOR over entire range	1.74	0.12–29.79	0.6881
Cases ≥200 min	0.79	0.33–1.87	0.5881
Estimated blood loss (mL)			
AOR over entire range	159.95	1.05–139,913	0.0472*
Cases ≥500 mL	2.63	1.00–7.21	0.0500*

All associations adjusted for patient age, location of colonic ischemia, and ASA class

AOR adjusted odds ratio, *ASA* American Society of Anesthesiologists, *BMI* body mass index, *COPD* chronic obstructive pulmonary disease, *ICMR* ischemic colitis mortality risk, *NOMI* non-occlusive mesenteric ischemia, *ARF* acute renal failure, *CV* cardiovascular, *IC* ischemic colitis

*Indicates statistical significance

Furthermore, this is the first study to date to report results of a subset of patients undergoing total or partial colectomy for IC followed longitudinally through subsequent end-ostomy reversal.

Table 5 End-ostomy reversal for surviving patients (n=17)

End-ostomy reversal	17/72 (24 %)
Death after reversal	3/17 (18 %)
ICU admission	6/17 (35 %)
Average ICU days	18±15
Length of hospitalization [median (25–75)]	27±25 [15 (12–34)]
Anastomotic leak	3/17 (18 %)

ICU intensive care unit

Acute IC continues to represent a very deadly disease associated with high rates of morbidity and mortality. In general, nearly all patients in our acute IC cohort required critical care admission with one in five requiring reoperation (excluding tracheostomy or feeding tube placement). Furthermore, severe postoperative complications such as septic shock, renal failure, and myocardial infarction were not infrequent. The arduous and tenuous postoperative course is further supported by patients requiring a mean hospitalization length of 26 days after surgery and a 37 % in-hospital mortality rate. This underscores that acute IC is an ominous

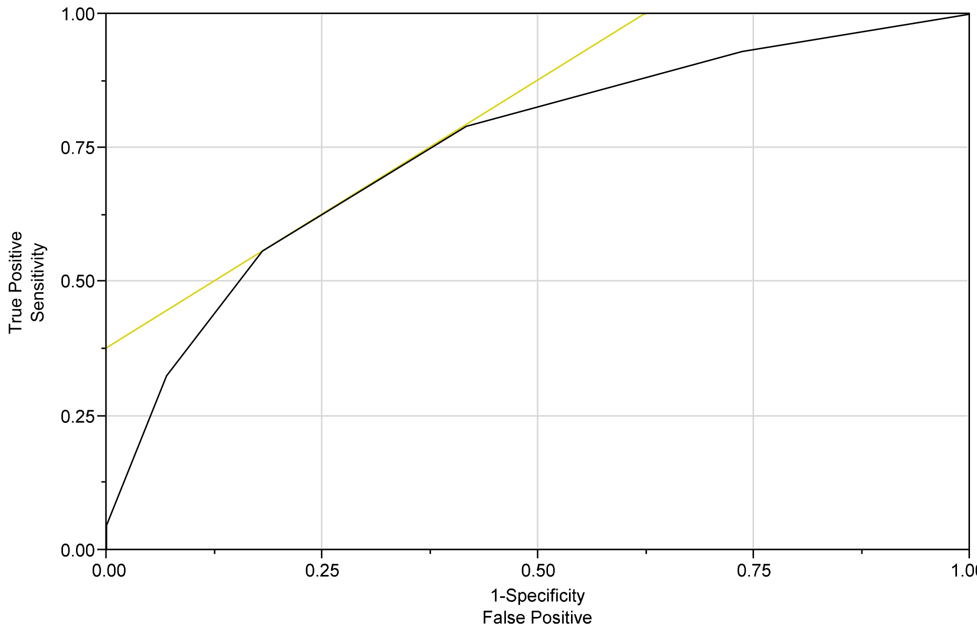


Fig. 2 Receiver operating characteristic curve of ICMR score prediction of in-hospital mortality. *Diagonal line* is tangent to the portion of the curve representing the single best cutoff point for predicting in-hospital mortality, which is the area between an ICMR Score of 2 and 3. *ICMR* ischemic colitis mortality risk

disease and should alert surgeons to have frank and transparent discussions with patients and family regarding end-of-life decisions. It is notable, however, that patients in our series who survived to hospital discharge had a median survival of 43.6 months. This suggests that patients surviving the initial acute IC event can achieve long-term survival and that development of acute IC may not necessarily be surrogate for overall patient frailty and impending all-cause mortality as has been demonstrated in other disease processes.[29] Given that the prognosis after acute IC is not entirely bleak for surgical survivors, it is the recommendation of the authors to proceed with surgery after establishing realistic expectations with patients and their families in regards to their expected postoperative course.

In light of this, however, the subgroup of patients (n=17) in our study who were followed through end-ostomy reversal demonstrated in-hospital mortality rate of 18 % (n=3) with a mean length of stay of 27 days and 35 % (n=6) requiring ICU care following this elective procedure. Of note, all three deaths occurred in patients who underwent major cardiovascular surgery preceding the onset of the initial acute IC event. The literature to date on elective ostomy reversal has been dominated by procedures performed after colectomy for diverticulitis,[30–32] with little known about postoperative outcomes specific to patients undergoing elective ostomy reversal following colectomy for acute IC. It is quite possible that ostomy reversal for acute IC patients carries a higher risk than the same procedure performed for other etiologies. Although our limited cohort precludes definitive conclusion on this issue, the results of our experience should heed warning for all surgeons to carefully evaluate appropriateness of ostomy reversal for acute IC survivors.

Limited information is available to assess risk factors and predictors of mortality when developing management strategies for acute IC. In our study population, postoperative death was associated with the peak preoperative lactate level, amount of intraoperative blood loss, need for intraoperative vasopressors, need for dialysis postoperatively, and an ASA Class ≥4. Applying the ICMR Score to our patient population provided reasonable accuracy in predicting postoperative mortality based on common measures used to assess discriminative ability.[27] Given the relatively rare occurrence of this disease,[6,9,16] it is unlikely that any single-center study will be adequately powered to fully delineate factors predictive of postoperative death. By risk-stratifying our patient cohort using the ICMR Score developed by Reissfelder et al. and evaluating the associated mortality, we have combined two of the largest series reported in the literature in order to substantiate a potential method for predicting risk of postoperative death following surgical intervention for acute IC.

However, the ICMR Score has several limitations that warrant discussion. First of all, subtotal colectomy and non-occlusive etiology, both of which are included as a component of the ICMR Score, did not seem to impact mortality in our patient population. This could indicate that the predictive value of these metrics in the Reissfelder study is a surrogate for other contributing factors, such as blood loss or hemodynamic instability. Secondly, determining the etiology of acute IC to be occlusive or non-occlusive may be difficult to elucidate in the acute setting, limiting the practicality of this component of the ICMR Score.[11] Lastly, including the outcome measure of postoperative renal failure requiring hemodialysis in the risk score calculation will obviate the ability to utilize this score in the preoperative or immediate postoperative period. Nonetheless, the ICMR Score may function as a dynamic scoring system to aid clinicians in determining when continued critical care for patients with an increasing ICMR Score is reaching futility.

The results reported here should also be interpreted in the context of the limitations to the analysis related to its retrospective nature. A retrospective determination of the etiology of acute IC may not fully capture intraoperative evidence of causality, which may limit the comparison of occlusive versus non-occlusive disease. A limitation to determining preoperative dialysis requirement in our study population is the inability to identify patients who may have received dialysis at an outside facility but not at our institution. Additionally, this study is limited to patients with acute IC severe enough to warrant colectomy, and does not assess the full spectrum of disease including other surgical interventions (such as revascularization) and non-operative management. Moreover, information regarding ostomy reversals outside of our institution was unavailable for analysis. Despite these limitations, the volume of patients included in our study relative to previous reports in the literature as well as the longitudinal follow-up through end-ostomy reversal provides important information for patients and clinicians facing this difficult disease process.

Conclusion

Acute IC continues to remain a very deadly disease associated with high rates of morbidity and mortality. Patients who survive the initial acute IC insult can achieve long-term survival; however, our series demonstrated a high rate of death and complications following elective end-ostomy reversal. The ICMR Score may be an effective tool to predict postoperative death for patients undergoing total or subtotal colectomy for acute IC.

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