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ORIGINAL ARTICLE

Risk factors of surgical mortality in patients with *Clostridium difficile* colitis. A novel scoring system

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Abstract

Background The purpose of the study is to identify the risk factors of mortality and develop a risk scoring system in patients who underwent colectomy due to *Clostridium difficile* colitis (CD-C).

Methods Patient information was extracted using the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) data from 2012 to 2016. All adult patients who underwent colectomy for CD-C were included in the study. The data were split into training and testing data sets. A multiple logistic regression model was developed by backward deletion methods for risk assessment. To test the performance of the prediction model for 30-day mortality, a receiver operating characteristic (ROC) curve was generated and an area under the curve (AUC) was created.

Results The training data set consisted of 434 (80%) patients, and the testing data set consisted of 91 (20%) patients. The overall mortality was 35%. No significant differences were found between the training and testing data sets for patient characteristics, comorbidities and mortality. The final model of the logistic regression model revealed a highly significant 30-day mortality for an age of ≥ 75 years old, ventilator dependency, Septic shock prior to surgery and a history of steroid use. The AUC value was 0.745 (95% CI 0.660–0.826). The risk of mortality scores range from 0 to 37. The highest score of 37 was related to an 83.9% predicted mortality.

Conclusion Older age, septic shock, ventilator dependency requiring supportive care and a history of chronic steroid use were highly associated with mortality. A nomogram showing the scores and their relationship to mortality may provide guidance to point of care physicians for deciding the goal of care.

Level of evidence Level of evidence: IV.

Keywords *Clostridium difficile* colitis · Colectomy · Risk of mortality

Introduction

In recent years, the incidence of *Clostridium difficile* colitis (CD-C) has been on the rise and poses a major burden on the healthcare industry [1]. According to a Center for Disease Control and Prevention report from 2017, 223,900 patients with CD-C were hospitalized, and approximately 6% of these patients died [2]. Most cases of CD-C are mild to moderate in severity and can be treated with antibiotics, [3] but 20–35% of patients can develop recurrent infections [4–7]. The most severe form of *C. difficile* infection, fulminant CD-C, occurs in 3–4% of patients [8].The progression from mild to severe colitis can be very rapid causing circulatory and respiratory failure, and can be associated with very high mortality [9]. The reported mortality from fulminant CD-C cases ranges from 34 to 57% [10, 11]. Appropriate antibiotic coverage, supportive care and early operative intervention lead to better outcomes in the most severe cases of CD-C [8, 12].

Sailhamer and colleagues analyzed the data from a single center, and reported the risk factors of mortality in fulminant cases of CD-C. An age above 70 years old, respiratory failure requiring mechanical ventilation, severe leukocytosis or leukopenia and shock requiring vasopressive support were

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all significantly associated with mortality [8]. Kassam and colleagues developed the Clostridium difficile Associated Risk of Death Score (CARDS), using the National Inpatient Sample (NIS) database of all patients who developed CD-C. They found advanced age, renal failure, cardiovascular and liver disease and the presence of malignancy were highly correlated with mortality [13]. The two studies examined the risk factors of all fulminant cases of CD-C, including operative and non-operative cases. They evaluated the risk factors of mortality in colectomy cases, with advanced age as the one of the most significant factors along with immunosuppression, shock and acute respiratory failure requiring mechanical ventilation, renal failure and leukocytosis or leukopenia [8, 14–17]. However, none of the studies were validated either by external study or by internal data except one [16]. The validation data set used in the study was approximately 15–20 years old data (1994–2007) that was significantly different compared to the actual study data regarding the proportion of immunosuppression and presence of septic shock [18]. Furthermore, none of the studies reported the relationship of actual mortality to predicted mortality for the accuracy of predictability. Therefore, we designed our study to develop a predictor model with validation to determine the risk factors of mortality in fulminant cases of CD-C in patients who underwent colectomy. The study will also aim to develop a simple scoring system for the point of care physician to identify the risk of mortality. We used patient demography, severity of illness and comorbid conditions in our risk model using the American College of Surgeons National Surgical Quality Improvement Program ((NSQIP) data from the calendar year of 2012 through 2016. Contrary to the scoring system developed based on single center data, [8] we opted to use national data for our scoring system for better generalizability. Our hypothesis is certain factors were associated with mortality in patients who were diagnosed with CD-C and underwent colectomy.

Methods

All patients from 18 to 89 years old, who were diagnosed with CD-C and underwent colectomy for fulminant infection, were accessed from the NSQIP database from the year 2012 to 2016. The NSQIP database was developed by the American College of Surgeons (ACS) to improve outcomes in surgical patients [19]. More than 700 institutions within and outside of the US participate and deposit data in the NSQIP. Other variables included in the study are sex, race, leukocytosis, septic shock, ventilator dependency and comorbidities (such as diabetes mellitus (DM), hypertension (HTN), chronic obstructive pulmonary disease (COPD), ascites, congestive heart failure (CHF), chronic renal failure (CKD), CKD with dialysis (CKD-DL), coagulopathy, disseminated cancer), use of chronic steroids, and history of smoking. Septic shock is defined as the presence of sepsis (temperature > 38 ℃ or < 36 ℃, heart rate > 90 beats per minute, WBC > 1200 cell/mm3 or < 4000 cell/mm3, acidosis, etc.), with organ dysfunction and/or circulatory collapse. Ventilator dependency is defined as acute respiratory failure requiring mechanical ventilation support for more than 48 h prior to surgery.

Patients were excluded from the study if the colectomy was performed for other reasons, for example, diverticulitis, ulcerative colitis, bleeding or malignancy.

Statistics

Patient characteristics including comorbidities and outcomes were first summarized using median with interquartile range (IQR) [first quartile – third quartile] for continuous variables, and frequency and percentage for categorical variables [20]. The normality of data was tested using the Shapiro–Wilk test. First univariate analyses were performed to compare the two groups using the Wilcoxon Rank Sum test for the continuous variables. The Chi-square test was performed for the categorical variables.

Multiple logistic regression analysis was performed using patient characteristics, comorbidities, laboratory findings and those variables described from previously published work that have shown a correlation with mortality included in the multivariable model [8, 13]. Age was first categorized based on the ranges used by the Acute Physiology and Chronic Health Evaluation (APACHE II) score; < 45, 45–54, 55–64, 65–74, 75 year or over [21]. From the univariate and multiple logistic regression analyses, we found the age group of 75 years old or above was statistically significantly different than the other age groups. For the other age groups, their associations with mortality were not statistically significant. Therefore, four age groups of < 45, 45–54, 55–64, 65–74 years old were grouped together in the final analysis. The final model was selected based on an initial stepwise-AIC process and a backward-deletion process. For the creation and validation of the risk assessment model, the data were divided into two data sets: a training data set that contains 80% of the randomly selected data, and a testing data set, which contains the other 20% of the data. The training and validation data were further compared for patient characteristics, comorbidities and outcomes. The receiver-operating characteristics (ROC) curve was constructed, and the corresponding area-under-the curve (AUC) was calculated. The Hosmer–Lemeshow goodness-of-fit test was used to evaluate the model fitting. All p values reported were two-sided, and a p value of < 0.05 was considered statistically significant. All data cleaning and statistical analyses were performed using both "R: A language and environment

for statistical computing" [22] and STATA15 [23]. A simple scoring system was also created by multiplying the β coefficient of the selected variables with a factor of 10 and rounded to the nearest whole number [24, 25].

The primary outcome of the study is a 30-day mortality. The secondary outcome is to develop a simple scoring system.

Results

Patient's characteristics and univariate analysis

Out of 525 patients who satisfied the inclusion criteria, 184 (35%) patients died within 30 days of admission. The median age of the patients was 67 years old. Patients were mostly female (55%) and predominantly Caucasians (84%). Prior to colectomy, 62.5% of the patients presented with septic shock. In addition, 33.5% of the patients presented with acute respiratory failure requiring mechanical ventilation prior to surgery. Approximately 82% of the patients presented with toxic mega colon, and 18% of the patients had a perforated bowel. About two-thirds of the patients underwent a total abdominal colectomy, and the remaining one-third underwent partial colectomy. There were significant differences found between the two groups in the baseline characteristics (Table 1).

Multivariable analysis

The variables selected for the logistic regression model were those characteristics that showed significant differences in the univariate analysis, including age, respiratory failure requiring mechanical ventilation (ventilator dependency), presence of septic shock prior to colectomy, comorbidities (including COPD, CKD-DL, coagulopathy) and ASA classification prior to surgery. The final model used age, ventilator dependency, septic shock and chronic steroid use. The regression β-coefficients provide the estimated change in the log-odds of mortality for a one unit or a category change for the predictor variable. The results showed that an age of ≥ 75 years old, ventilator dependency, presence of septic shock and history of steroid use were highly significant for higher odds of 30-day mortality (Table 2).

To test the performance of the prediction model for 30-day mortality, a receiver operating characteristic (ROC) curve was generated, and the area under the curve (AUC) value was measured and equaled to 0.745 (95% CI 0.660–0.826) (Fig. 1).

The comparison of the training data set and validating data set did not show any significant difference for patient demography, clinical characteristics, laboratory findings and 30-day mortality (Table 3).

To validate the model, a sensitivity analysis was also performed by comparing the observed mortality rates and expected mortality rates, based on a fitted regression model (Fig. 2) with a Hosmer–Lemeshow p value of 0.09 indicating no significant evidence for a lack of model fit. The risk of mortality scores ranged from 0 to 37 (Table 4). A lower score has a lower probability of mortality, and a higher score has a higher probability of mortality. Our model showed that a patient who presents with a 0 score can have a mortality of 12.5%, and if the score is 37, the predicted mortality is 83.9% (Table 5).

When the scores were further tested to see the comparison of actual mortality to predicted mortality in the training and testing data sets, they showed a linear upward trajectory. As the score increases, the mortality rate increased. Since the number of patients in the higher score range was low, the predicted mortality was relatively higher than the observed mortality (Fig. 3). Using the prediction model, if all four characteristics (age ≥ 75 years old, respiratory failure, shock and history of steroid use) are present, the mortality of the patient is 83.9%.

Discussion

Our study showed a 35% overall mortality in patients who underwent colectomy for CD-C infection. Advanced age, history of steroid use, ventilator dependency and septic shock are predictors of mortality. If all four predictors (age ≥ 75 years old, septic shock, ventilator dependency, and history of steroid use) are present before the colectomy, the overall mortality is 83.9%. If three variables (age, respiratory failure and septic shock) are present, the mortality is 74%.

A study from the NIS database reported the CD-C related mortality [13]. The study included 77,776 patients who were diagnosed with CD-C. The overall mortality was 8%, and the factors associated with mortality were advanced age, history of renal failure, liver and cardiopulmonary diseases, etc. Sailhamer and colleagues analyzed the data of all fulminant cases of CD-C over a 12-year period and found an overall mortality of 35%. The common factors associated with mortality were advanced age > 70 years old, severe leukocytosis or leukopenia, [8]. When all predictors were present, the mortality rate increased to 57% [8]. We tried to compared our results,the C-statistics, from Sailhamer study, we were unable to do so because the authors did not provide C-statistics of colectomy patients and the NSQIP database does not provide information of neutrophils band. Kulaylat and colleagues examined the NSQIP database from 2005 through 2014 and included more than 500 patients in their analysis. They found an age ≥ 80 years old, ventilator dependency, shock, chronic steroid use and renal

Table 1 Comparison of patients who survived vs. who died

Variable	Values	All patients ($n=525$)	Survived ($n=341$)	Died ($n=184$)	P value
Age, in years	Median (Q1–Q3)	67 (57–76)	66 (55–74)	70 (59.75–78)	0.002
Sex	Female	292 (55.6)	186 (54.5)	106 (57.6)	0.561
	Male	233 (44.4)	155 (45.5)	78 (42.4)	
Race (white)	No	84 (16)	54 (15.8)	30 (16.3)	0.988
	Yes	441 (84)	287 (84.2)	154 (83.7)	
Leukocytosis, WBCs count, $*10^9$/L					
	4–11.9	107 (20.4)	75 (22)	32 (17.4)	0.052
	12–19.9	101 (19.2)	70 (20.5)	31 (16.8)	
	20–34.9	119 (22.7)	81 (23.8)	38 (20.7)	
	35–44.9	58 (11)	39 (11.4)	19 (10.3)	
	>45	46 (8.8)	29 (8.5)	17 (9.2)	
	<4	31 (5.9)	17 (5)	14 (7.6)	
	Unknown	63 (12)	30 (8.8)	33 (17.9)	
Blood transfusion	No	479 (91.2)	316 (92.7)	163 (88.6)	0.157
	Yes	46 (8.8)	25 (7.3)	21 (11.4)	
Presence of sepsis					
	None	40 (7.6)	30 (8.8)	10 (5.4)	<0.001
	Sepsis	128 (24.4)	101 (29.6)	27 (14.7)	
	Septic shock	328 (62.5)	186 (54.5)	142 (77.2)	
	SIRS	29 (5.5)	24 (7)	5 (2.7)	
Ventilator dependency	No	349 (66.5)	258 (75.7)	91 (49.5)	<0.001
	Yes	176 (33.5)	83 (24.3)	93 (50.5)	
Reasons for colectomy	Perforation	95 (18.1)	69 (20.2)	26 (14.1)	0.106
	Toxic colitis	430 (81.9)	272 (79.8)	158 (85.9)	
Wound class					
	Clean	4 (0.8)	2 (0.6)	2 (1.1)	0.645
	Clean Contaminated	94 (17.9)	63 (18.5)	31 (16.8)	
	Contaminated	173 (33)	107 (31.4)	66 (35.9)	
	Dirty/infected	254 (48.4)	169 (49.6)	85 (46.2)	
ASA class					
	1-No disturb	1 (0.2)	1 (0.3)	0 (0)	<0.001
	2-Mild disturb	9 (1.7)	9 (2.6)	0 (0)	
	3-Severe disturb	93 (17.7)	76 (22.3)	17 (9.2)	
	4-Life threat	326 (62.1)	207 (60.7)	119 (64.7)	
	5-Moribund	96 (18.3)	48 (14.1)	48 (26.1)	
Comorbidities, n (%)					
Diabetes	Insulin	74 (14.1)	52 (15.2)	22 (12)	0.551
	No	412 (78.5)	265 (77.7)	147 (79.9)	
	Non-insulin	39 (7.4)	24 (7)	15 (8.2)	
Smoke	No	401 (76.4)	259 (76)	142 (77.2)	0.836
	Yes	124 (23.6)	82 (24)	42 (22.8)	
Dyspnea					
	At rest	32 (6.1)	16 (4.7)	16 (8.7)	0.008
	Moderate exertion	57 (10.9)	29 (8.5)	28 (15.2)	
	No	436 (83)	296 (86.8)	140 (76.1)	
Functional dependency					
	Independent	402 (76.6)	267 (78.3)	135 (73.4)	0.315
	Partially dependent	95 (18.1)	59 (17.3)	36 (19.6)	
	Totally dependent	28 (5.3)	15 (4.4)	13 (7.1)	

Table 1 (continued)

Variable	Values	All patients ($n=525$)	Survived ($n=341$)	Died ($n=184$)	P value
COPD	No	397 (75.6)	273 (80.1)	124 (67.4)	0.002
	Yes	128 (24.4)	68 (19.9)	60 (32.6)	
Ascites	No	467 (89)	310 (90.9)	157 (85.3)	0.072
	Yes	58 (11)	31 (9.1)	27 (14.7)	
CHF	No	484 (92.2)	317 (93)	167 (90.8)	0.468
	Yes	41 (7.8)	24 (7)	17 (9.2)	
Hypertension	No	205 (39)	133 (39)	72 (39.1)	> 0.99
	Yes	320 (61)	208 (61)	112 (60.9)	
Renal failure	No	428 (81.5)	279 (81.8)	149 (81)	0.905
	Yes	97 (18.5)	62 (18.2)	35 (19)	
Dialysis	No	454 (86.5)	303 (88.9)	151 (82.1)	0.042
	Yes	71 (13.5)	38 (11.1)	33 (17.9)	
Steroid	No	427 (81.3)	288 (84.5)	139 (75.5)	0.017
	Yes	98 (18.7)	53 (15.5)	45 (24.5)	
Disseminated cancer	No	481 (91.6)	314 (92.1)	167 (90.8)	0.722
	Yes	44 (8.4)	27 (7.9)	17 (9.2)	
Coagulopathy	No	410 (78.1)	278 (81.5)	132 (71.7)	0.013
	Yes	115 (21.9)	63 (18.5)	52 (28.3)	

ASA American society of anesthesiology, *CHF* congestive heart failure,

COPD chronic obstructive pulmonary disease, *IQR* 1st and 3rd interquartile range, *SIRS* systemic inflammatory response syndrome, *WBCs* white blood cell counts

failure were highly significant for the mortality in colectomy patients [14]. However, the results of these studies were not validated. Abou Khalil and colleagues developed risk factors of mortality and validated the results from a single center old data set. They found a 44% overall mortality in CD-C with total abdominal colectomy [16]. However, some of the characteristics of the patients in the validation data set were not similar to the training data set. A higher proportion of patients in validation data set suffered from immunosuppression and septic shock.

Currently no single scoring system has been universally adopted for predicting the mortality in patients with CD-C who will undergo abdominal colectomy. The most commonly used risk calculator for surgical outcomes, the NSQIP risk of mortality calculator for emergency total abdominal colectomy, was used in our patient population with an age ≥ 75 years old, history of chronic steroid use, vent dependency and septic shock with a life threatening classification on ASA. The risk of mortality was 62.6% in males and 58.5% in females. The risk of mortality ACS-NISQIP calculator underestimated the mortality compared to our study [19], because it is purely procedural-based and does not take into consideration disease conditions. A recent study from New Zealand assessed the predictability of mortality in emergency laparotomy by comparing the ACS-NSQIP calculator to emergency laparotomy national audit (ELNA) found the ACS-NSQIP calculator under predicted the mortality [26]. Therefore, it is important to understand that when the NSQIP calculator is used for disease-related surgical mortality, it may not reflect accurate outcomes.

The same NSQIP database as a prior study was utilized, but also incorporated more recent data (2012–2016). We split the data set into a training data set and the testing data set. The testing data set was used to validate the results. Both data sets showed no difference in demography, clinical measurements, comorbidities and outcomes (Table 3). The age cutoff in our final risk model is 75 years old, which is different from other studies, [8, 14] because we first categorized the age as described in the commonly used risk adjusted mortality scoring system in critically ill patients [16]. Our model showed an AUC value of 0.745 [95% CI: 0.660, 0.826] with a p of value = 0.09, which means the risk model is an adequate fit. Our risk model showed advanced age, ventilator dependency, septic shock and a history of steroid use were highly significant for mortality as reported by the other study [14]. However, our study did not show renal failure, leukocytosis or leukopenia, and cardiac comorbidities as risk factors as presented in previous studies [8, 13–17]. If all four-risk characteristics are present, the mortality rate can increase to 83%. Our highest mortality rate is relatively higher than the study reported by Sailhamer, [8] and less than the study performed by Kulaylat [14]. The variability in mortality based on the maximum risk factors in the different studies may be due to a different age cut

Table 2 Results from Multiple Logistic Regression Analysis

Variables	β coefficient	95% CI for β		OR	95% CI for OR		p value
(Intercept)	− 1.994	− 2.395	− 1.618	0.136	0.091	0.198	< 0.001
Ventilator dependency (yes)	1.064	0.655	1.479	2.898	1.924	4.386	< 0.001
Steroid (yes)	0.564	0.066	1.061	1.758	1.069	2.888	0.026
Shock (septic shock)	1.258	0.863	1.662	3.519	2.370	5.271	< 0.001
Age (> = 75 years)	0.719	0.289	1.153	2.053	1.335	3.167	0.001

Log-Odds of died

= − 1.994 + 1.064*Ventilat (Yes) + 0.564*steroid (Yes) + 1.258*shock (Septic Shock) + 0.719*age (>=75 years)

$$\text{Probability of died} = \frac{\text{EXP(LOG-Odds of died)}}{1+\text{EXP(LOG-Odds of died)}}$$

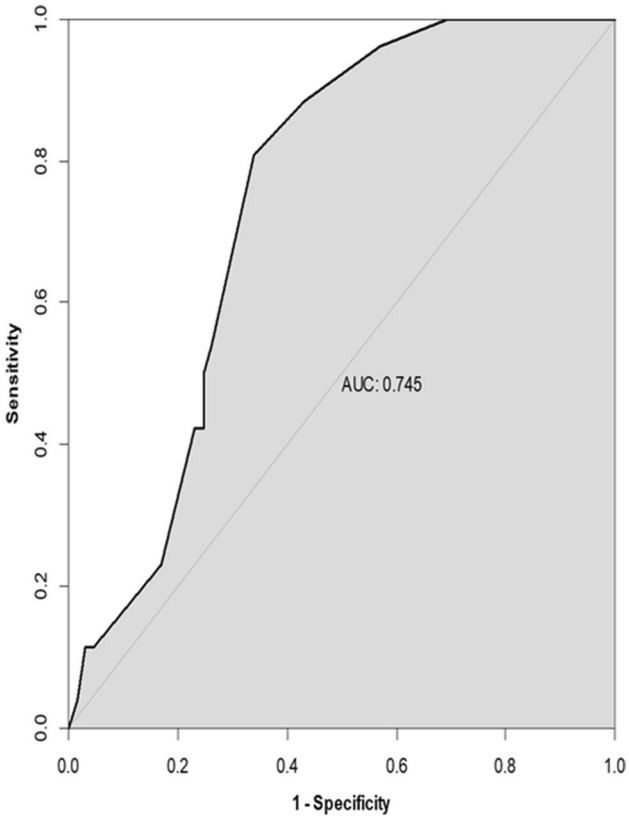

Fig. 1 Receiving operating characteristics (ROC) curve for prognostic model performance in predicting mortality in fulminant *Clostridium difficile* colitis patients with colectomy

off. Our study is the first study that internally validated the results, and presented a comparison of the actual mortality with predicted mortality (Fig. 2). The present scoring system is more generalizable than the single center study [8] to predict the surgical mortality of the fulminant cases of CD-C patients. Our novel scoring system predicted the mortality as a linear upward progression. Higher scores relate to a higher mortality, and the predicted mortality was close to observed mortality except at the extreme score. This deviation might be due to the lower number of available patients for analysis (Fig. 3).

Limitations

Our study answered a very relevant question of mortality associated with surgical intervention for fulminant CD-C. However, the retrospective nature of the study carries an inherent weakness, as the incidence has already occurred. To balance the co-variates and identify the risk factors for mortality, we used multivariable analysis. Furthermore, we used a sensitivity analysis test in our model. However, unavailability of detailed clinical information including type of antibiotic therapy and

Table 3 Comparison between training and validation data sets

		All patients ($n=525$)	Training ($n=434$)	Validation ($n=91$)	P value
Age, in years	Median (Q1-Q3)	67 (57–76)	68 (58–76)	66 (54.5–76.5)	0.521
Sex	Female	292 (55.6)	250 (57.6)	42 (46.2)	0.06
	Male	233 (44.4)	184 (42.4)	49 (53.8)	
Race (white)	No	84 (16)	65 (15)	19 (20.9)	0.215
	Yes	441 (84)	369 (85)	72 (79.1)	
Leukocytosis, WBCs count,$*10^9$/L					
	4–11.9	107 (20.4)	87 (20)	20 (22)	0.788
	12–19.9	101 (19.2)	86 (19.8)	15 (16.5)	
	20–34.9	119 (22.7)	101 (23.3)	18 (19.8)	
	35–44.9	58 (11)	46 (10.6)	12 (13.2)	
	>45	46 (8.8)	40 (9.2)	6 (6.6)	
	<4	31 (5.9)	25 (5.8)	6 (6.6)	
	Unknown	63 (12)	49 (11.3)	14 (15.4)	
Comorbidity, *n* (%)					
Diabetes	Insulin	74 (14.1)	58 (13.4)	16 (17.6)	0.172
	No	412 (78.5)	347 (80)	65 (71.4)	
	Non-insulin	39 (7.4)	29 (6.7)	10 (11)	
Smoke	No	401 (76.4)	337 (77.6)	64 (70.3)	0.174
	Yes	124 (23.6)	97 (22.4)	27 (29.7)	
Dyspnea					
	At rest	32 (6.1)	25 (5.8)	7 (7.7)	0.698
	Moderate exertion	57 (10.9)	46 (10.6)	11 (12.1)	
	No	436 (83)	363 (83.6)	73 (80.2)	
Functional dependency					
	Independent	402 (76.6)	332 (76.5)	70 (76.9)	0.927
	Partially dependent	95 (18.1)	78 (18)	17 (18.7)	
	Totally dependent	28 (5.3)	24 (5.5)	4 (4.4)	
COPD	No	397 (75.6)	325 (74.9)	72 (79.1)	0.471
	Yes	128 (24.4)	109 (25.1)	19 (20.9)	
Ascites	No	467 (89)	382 (88)	85 (93.4)	0.191
	Yes	58 (11)	52 (12)	6 (6.6)	
CHF	No	484 (92.2)	403 (92.9)	81 (89)	0.304
	Yes	41 (7.8)	31 (7.1)	10 (11)	
Hypertension	No	205 (39)	166 (38.2)	39 (42.9)	0.483
	Yes	320 (61)	268 (61.8)	52 (57.1)	
Renal failure	No	428 (81.5)	358 (82.5)	70 (76.9)	0.273
	Yes	97 (18.5)	76 (17.5)	21 (23.1)	
Dialysis	No	454 (86.5)	378 (87.1)	76 (83.5)	0.460
	Yes	71 (13.5)	56 (12.9)	15 (16.5)	
Steroid	No	427 (81.3)	354 (81.6)	73 (80.2)	0.879
	Yes	98 (18.7)	80 (18.4)	18 (19.8)	
Disseminated cancer	No	481 (91.6)	395 (91)	86 (94.5)	0.376
	Yes	44 (8.4)	39 (9)	5 (5.5)	
Coagulopathy	No	410 (78.1)	338 (77.9)	72 (79.1)	0.904
	Yes	115 (21.9)	96 (22.1)	19 (20.9)	
Blood transfusion (perioperative)	No	479 (91.2)	395 (91)	84 (92.3)	0.847
	Yes	46 (8.8)	39 (9)	7 (7.7)	

Table 3 (continued)

		All patients ($n=525$)	Training ($n=434$)	Validation ($n=91$)	P value
Presence of sepsis prior to surgery					
	None	40 (7.6)	29 (6.7)	11 (12.1)	0.224
	Sepsis	128 (24.4)	104 (24)	24 (26.4)	
	Septic shock	328 (62.5)	275 (63.4)	53 (58.2)	
	SIRS	29 (5.5)	26 (6)	3 (3.3)	
Ventilator dependency before surgery	No	349 (66.5)	286 (65.9)	63 (69.2)	0.624
	Yes	176 (33.5)	148 (34.1)	28 (30.8)	
Wound class					
	Clean	4 (0.8)	3 (0.7)	1 (1.1)	0.615
	Clean/contaminated	94 (17.9)	78 (18)	16 (17.6)	
	Contaminated	173 (33)	147 (33.9)	26 (28.6)	
	Dirty/infected	254 (48.4)	206 (47.5)	48 (52.7)	
ASA class					
	1-No disturb	1 (0.2)	1 (0.2)	0 (0)	0.782
	2-Mild disturb	9 (1.7)	7 (1.6)	2 (2.2)	
	3-Severe disturb	93 (17.7)	74 (17.1)	19 (20.9)	
	4-Life threat	326 (62.1)	273 (62.9)	53 (58.2)	
	5-Moribund	96 (18.3)	79 (18.2)	17 (18.7)	
Mortality	Yes	184 (35)	158 (36.4)	26 (28.6)	0.192

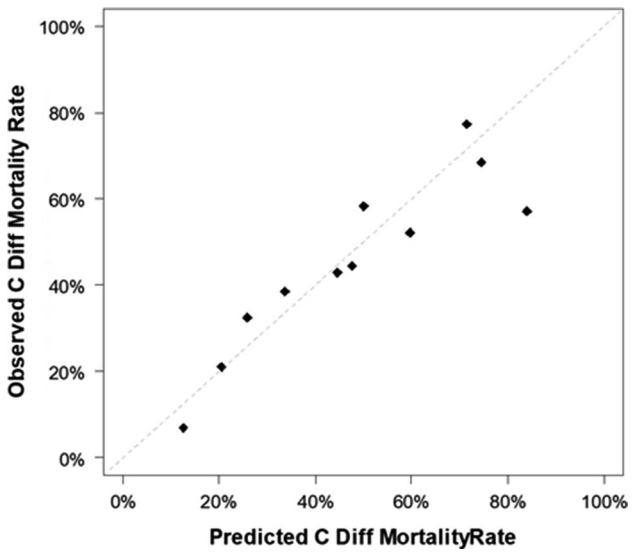

Fig. 2 Observed over fitted average mortality in fulminant *Clostridium difficile* colitis patients with colectomy

Table 4 Risk of mortality score

Variable	Coefficient	Score
Ventilator use: yes	1.0640	11
Steroid: yes	0.5640	6
Shock (septic shock)	1.2583	13
Age: > = 75 years	0.7192	7

Table 5 Risk score and 30-day mortality

Risk score	Predicted mortality in %
0	12.53
6	20.43
7	22.06
11	29.46
13	33.66
17	42.81
18	45.21
19	47.62
20	50.05
24	59.66
26	64.24
30	72.61
31	74.50
37	83.96

certain risk adjusted scores for example, Sequential Organ Failure Assessment (SOFA) and the Acute Physiology and Chronic Health Evaluation (APACHE II) score, may have influenced the results.

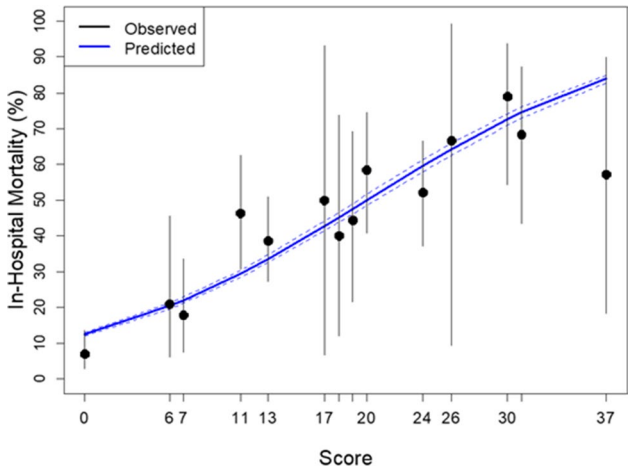

Fig. 3 Observed over predicted mortality in relation to risk of mortality score

Conclusion

Our study specifies predictive risk factors for mortality in surgical CD-C patients with internal validation. The mortality rate remains high in colectomy patients with fulminant CD-C. Continued improvement in critical care management and compliance with the recent guideline recommendations for early surgery may mitigate the risk of mortality. Our scoring system can be used at the bedside when a colectomy due to fulminant CD-C is being considered. The predictor of mortality may be one of the most important issues to consider when patients, patient families and providers decide the goals of care.

Author contributions Nasim Ahmed (NA) conceived and designed the study. NA was responsible for retrieving the study data, while YenHong Kuo (YHK) performed the data analysis. NA and YHK, Robyn K. Guinto (RKG) and Jordan Purewal (JP) all contributed to manuscript writing. NA designed the study, accessed the data and contributed to the manuscript. YHK performed the statistical analyses and contributed in the creation of manuscript. NA and YHK interpreted the data. NA is also responsible for overall integrity of the study. Donald Winters, RP MPA performed the critical reading and final editing of the manuscript.

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Declarations

Conflict of interest All authors declare no conflict of interest.

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