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Surgical Resection for Crohn's and Cancer: A Comparison of Disease-Specific Risk Factors and Outcomes

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Keywords
Crohn's disease · Colon cancer · Right colectomy · Morbidity

Abstract
Background and Objectives: The goal of this study was to compare disease-specific risk factors and 30-day outcomes between patients with Crohn's disease (CD) and colon cancer (CC) undergoing right-sided surgical resection. ***Methods:*** The American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP®) was interrogated to extract all patients ≥18 years undergoing elective right-sided resection for CD versus CC. Independent risk factors for surgical complications were identified through multivariable logistic regression for both groups. In a second step, surgical and medical 30-day morbidity was compared after risk adjustment. ***Results:*** The cohort consisted of 17,516 patients, of which 2,899 (16.6%) underwent surgery for CD versus 14,617 (83.4%) for CC. Independent risk factors for surgical complications in patients with CD were male gender, African American race, ASA score (III or IV), active smoking, prolonged surgery, and preoperative anemia. Independent risk factors for surgical complications in the cancer group were age ≥70 years, male gender, ASA score (III or IV), respiratory and cardiovascular comorbidities, and preoperative hypoalbuminemia (<3.5 g/dL). After risk adjustment, surgical complications (OR 1.25, $p = 0.002$), sepsis (OR 1.64, $p = 0.012$), and unplanned readmissions (OR 1.39, $p = 0.004$) were more common in patients with CD. Thirty-day mortality was higher in cancer patients (1.1 vs. 0.1%, $p < 0.0001$). ***Conclusions:*** Patients with Crohn's disease were more prone to surgical complications and postoperative sepsis compared to the cancer group undergoing the same procedure. Careful evaluation and correction of disease-specific modifiable risk factors of patients with CD and CC, respectively, are important.

Introduction

Crohn's disease (CD) is a challenging condition related to the chronicity of the disease in typically heavily pretreated and deconditioned patients with complicated or medically refractory disease [1]. As a result, there is often no *true* elective setting for CD surgery [2]. Widespread colon cancer (CC) screening, on the other hand, has led to an increasing number of primary elective segmental

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colectomies, which has become one of the most commonly performed procedures nationwide [3].

Several studies have implicated that CD diagnosis portends worse outcomes after right-sided resection when compared to those with a diagnosis of right-sided CC [4–6]. Given the heterogeneity of baseline characteristics of both patient populations, comparing surgical outcomes requires adjustment for disease-specific risk factors. Identification of these risk factors for both CD and CC surgery is important for tailoring of surgical management and appropriate decision-making process, as well as adequate counseling that ultimately translates into proper patient care [7, 8]. The goal of this study was to compare disease-specific risk factors and 30-day outcomes between patients with CD and CC undergoing right-sided surgical resection.

Methods

Data Source

Data were accessed from the American College of Surgeons-National Surgical Quality Improvement Program (ACS-NSQIP) Public Use File (PUF) January 2012 to December 2017. ACS-NSQIP is an established, externally validated clinical database that was created for quality improvement purposes [9]. Demographic, anthropometric, perioperative, and postoperative data from the participant sites are collected by trained abstractors using standardized definitions.

Cohort Selection

All adult (≥18 years) patients undergoing elective right colectomy and index ileocecal resection for CC and CD, respectively, were included using the *International Classification of Diseases* (ICD 9) 153.x for CC and 555.x for CD or (ICD10) C18.x for CC and K50.xx for CD and Current Procedure Terminology (CPT) codes (44,160 for open partial colectomy with terminal ileum resection with ileocolostomy and 44,205 for laparoscopic partial colectomy with terminal ileum resection with ileocolostomy). Patients with diverting ileostomy were not retained.

According to ACS-NSQIP, elective surgery was defined as surgery for patients in whom the operation was not reported by the surgeon as an emergent and the patient presented from home for a prescheduled surgery. Patients undergoing urgent or emergent surgery, suffering from preoperative septic shock, graded American Society of Anesthesiologists (ASA) class V, or undergoing a concurrent operation under the responsibility of a different primary surgeon were excluded.

Baseline demographics, comorbidities, laboratory parameters (albumin, hematocrit, and platelet count), and surgical details (approach and operating time) were compared between the 2 groups (CD vs. CC). Specific risk factors for surgical complications including chronic steroid use (regular administration of corticosteroid medications or immunosuppressant medications for a chronic medical condition within the 30 days before the primary procedure), anemia, severe malnutrition (preoperative weight loss ≥10%/6 preoperative months and body mass index [BMI] <18.5 kg/m^2), functional status, ASA class, cardiovascular/respiratory comorbidities, and diabetes mellitus were assessed and compared between the 2 groups through uni- and multivariate analysis. Study outcomes of interest were postoperative 30-day complications according to standardized ACS-NSQIP definitions, which were regrouped as surgical (including surgical site infection, wound disruption, systemic sepsis [regrouping both septic shock and/or sepsis], postoperative ileus, unplanned reoperation, and need for blood transfusion) and medical (including urinary tract infection, respiratory complications [unplanned intubation, pneumonia, and failure to wean from mechanical ventilation], renal complications [acute kidney injury and progressive renal insufficiency], cardiac complications [pulmonary embolism, cardiac arrest, and myocardial infarction], and vascular thromboembolism). Unplanned readmission, unplanned reoperation, index length of stay (LOS), and 30-day mortality were also assessed.

Statistical Analysis

Descriptive statistics are reported as percentages for categorical variables and as median (interquartile range) for continuous variables. The differences between the variables were examined using the χ^2 test for categorical variables or the Wilcoxon rank-sum test for continuous variables. Outcomes with an α level of <0.1 after univariable analysis were included in the multivariable models to compute adjusted odds ratios (OR). Multivariable binary logistic regression was used to identify risk factors for overall complications in patients with CD and patients with CC and to study the association between CD and CC and postoperative outcomes. For this study, an α level of <0.05 was considered statistically significant. Data analysis was performed using Statistical Package for the Social Sciences (SPSS) Advanced Statistics 25 (IBM Software Group, Inc., Armonk, NY, USA).

Results

In total, 17,516 patients were included; 2,899 (16.6%) had ileocolonic CD versus 14,617 (83.4%) with right-sided CC. Preoperative baseline demographics, comorbidities, and laboratory values of both groups are detailed in Table 1. Patients with CD were significantly younger with a higher preponderance of (severe) malnutrition, recent weight loss ≥10%, and chronic steroid use. Cancer patients suffered from more comorbidities, including diabetes mellitus, cardiovascular, renal, and respiratory conditions with associated higher ASA score. While minimally invasive approach was used in both groups, they were less commonly performed in patients with CD. Furthermore, length of operation was longer in the CD group.

Postoperative Outcomes

Patients with CD were more prone to sepsis and readmissions. Cancer patients suffered more medical compli-

Table 1. Demographic, preoperative, and surgical data

	CD, $n = 2,899$	CC, $n = 14,617$	Overall, $N = 17,516$	p value
Age, years				
Median (IQR)	38 (29–52)	71 (62–79)	68 (56–77)	**<0.0001**
Age categories, years				
<50	2,061 (71.1%)	778 (5.3%)	2,839 (16.2%)	**<0.0001**
51–69	724 (25.0%)	5,894 (40.3%)	6,618 (37.8%)	
≥70	114 (3.9%)	7,945 (54.4%)	8,059 (46.0%)	
Gender, male	1,276 (44.0%)	6,885 (47.1%)	8,161 (46.6%)	**0.002**
Race				
White	2,381 (82.1%)	10,419 (71.3%)	12,800 (73.1%)	**<0.0001**
African American	256 (8.8%)	1,401 (9.6%)	1,657 (9.5%)	
Asian	19 (0.7%)	398 (2.7%)	417 (2.4%)	
Others	8 (0.3%)	56 (0.4%)	64 (0.4%)	
Unknown/not reported	235 (8.1%)	2,343 (16.0%)	2,578 (14.7%)	
BMI, kg/m^2				
Median (IQR)	25 (22–29)	28 (24–28)	27 (24–32)	**<0.0001**
Normal	1,266 (43.7%)	4,102 (28.1%)	5,368 (30.6%)	
Underweight	203 (7%)	287 (2%)	490 (2.8%)	
Overweight	801 (27.6%)	4,913 (33.6%)	5,714 (32.6%)	
Obese	622 (21.5%)	5,244 (35.9%)	5,866 (33.5%)	
Missing	7 (0.2%)	71 (0.5%)	78 (0.4%)	
ASA class (III or IV)	913 (31.5%)	9,353 (64%)	10,266 (58.6%)	**<0.0001**
Diabetes mellitus	70 (2.4%)	3,062 (20.9%)	3,132 (17.9%)	**<0.0001**
Current smoker	635 (21.9%)	1,671 (11.4%)	2,306 (13.2%)	**<0.0001**
History of severe COPD	32 (1.1%)	955 (6.5%)	987 (5.6%)	**<0.0001**
Functional health status				
Independent	2,886 (99.6%)	14,193 (97.1%)	17,079 (97.5%)	**<0.0001**
Dependent	7 (0.2%)	337 (2.3%)	344 (2.0%)	
Missing	6 (0.2%)	87 (0.6%)	93 (0.5%)	
CHF within 30 days of surgery	3 (0.1%)	131 (0.9%)	134 (0.8%)	**<0.0001**
Hypertension requiring medication	449 (15.5%)	8,763 (60.0%)	9,212 (52.6%)	**<0.0001**
Hemodialysis	4 (0.1%)	70 (0.5%)	74 (0.4%)	**0.01**
Chronic steroid use	1,692 (58.4%)	503 (3.4%)	2,195 (12.5%)	**<0.0001**
Preoperative loss of body weight; ≥10%/6 months	169 (5.8%)	570 (3.9%)	739 (4.2%)	**<0.0001**
Severe malnutrition, loss of body weight ≥10%/6 months, and BMI <18.5 kg/m^2	40 (1.4%)	50 (0.3%)	90 (0.5%)	**<0.0001**
PRBC transfusion within 72 h of surgery	6 (0.2%)	191 (1.3%)	197 (1.1%)	**<0.0001**
Minimally invasive surgery	1,739 (60.0%)	10,267 (70.2%)	12,006 (68.5%)	**<0.0001**
Operation time, min, median (IQR)	141 (106–185)	130 (97–172)	132 (98–174)	**<0.0001**
Preoperative albumin				
Median (IQR)	3.9 (3.5–4.2)	3.9 (3.5–4.2)	3.9 (3.5–4.2)	0.2
<3.5 g/dL	592 (20.4%)	2,621 (17.9%)	3,213 (18.3%)	**0.003**
Missing	839 (28.9%)	4,186 (28.6%)	5,025 (28.7%)	
Preoperative hematocrit				
Median (IQR)	39 (35.4–42)	25.9 (31.9–40)	37 (32.6–41)	**<0.0001**
<35%	615 (21.2%)	6,175 (42.2%)	6,790 (38.8%)	**<0.0001**
Missing	185 (6.4%)	441 (3%)	626 (3.6%)	
Preoperative platelet count				
Median (IQR)	293 (237–368)	265 (213–334)	268 (216–336)	**<0.0001**
<150,000/mL	61 (2.1%)	731 (5%)	792 (4.5%)	**<0.0001**
Missing	215 (7.4%)	571 (3.9%)	786 (4.5%)	

CD, Crohn's disease; CC, colon cancer; BMI, body mass index; DM, diabetes mellitus; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; PRBC, packed red blood cells; ASA, American Society of Anesthesiologists; IQR, interquartile range. Figures in bold indicate statistical significance.

Table 2. Postoperative complications

	CD, n = 2,899	CC, n = 14,617	Overall, N = 17,516	p value	Adjusted OR (95% CI)[a]
Surgical complications[b]	1,094 (37.7%)	5,773 (39.5%)	6,867 (39.2%)	0.077	**1.250 (1.088–1.435), *p* value 0.002**
Any SSI	282 (9.7%)	1,036 (7.1%)	1,318 (7.5%)	**<0.0001**	1.181 (0.943–1.480), p value 0.148
Superficial incisional	124 (4.3%)	552 (3.8%)	676 (3.9%)	0.2	na
Deep incisional	20 (0.7%)	82 (0.6%)	102 (0.6%)	0.4	na
Organ/space	154 (5.3%)	431 (2.9%)	585 (3.3%)	**<0.0001**	1.318 (0.960–1.809), p value 0.088
Wound disruption	15 (0.5%)	91 (0.6%)	106 (0.6%)	0.5	na
Systemic sepsis	112 (3.9%)	434 (3%)	546 (3.1%)	**0.011**	1.237 (0.875–1.750), p value 0.229
Sepsis	101 (3.5%)	271 (1.9%)	372 (2.1%)	**<0.0001**	**1.640 (1.114–2.413), *p* value 0.012**
Septic shock	12 (0.4%)	165 (1.1%)	177 (1%)	**0.001**	**0.419 (0.186–0.946), *p* value 0.036**
Ileus					
Yes	224 (7.7%)	1,185 (8.1%)	1,409 (8%)	**<0.0001**	1.010 (0.791–1.289), p value 0.947
Missing	844 (29.1%)	5,054 (34.6%)	5,898 (33.7%)		0.903 (0.785–1.039), p value 0.155
Leak					
Yes	81 (2.8%)	229 (1.6%)	310 (1.8%)	**<0.0001**	1.089 (0.701–1.692), p value 0.704
Missing	844 (29.1%)	5,062 (34.6%)	5,906 (33.7%)		0.899 (0.784–1.032), p value 0.131
Unplanned reoperation	110 (3.8%)	527 (3.6%)	637 (3.6%)	0.6	
Need for blood transfusion	125 (4.3%)	1,388 (9.5%)	1,513 (8.6%)	**<0.0001**	**0.649 (0.488–0.863), *p* value 0.003**
Medical complications[c]	104 (3.6%)	1,022 (7%)	1,126 (6.4%)	**<0.0001**	0.806 (0.594–1.094), p value 0.167
UTI	31 (1.1%)	237 (1.6%)	268 (1.5%)	**0.03**	0.970 (0.544–1.731), p value 0.918
Respiratory complication[d]	34 (1.2%)	454 (3.1%)	488 (2.8%)	**<0.0001**	0.747 (0.456–1.224), p value 0.247
Renal complications[e]	12 (0.4%)	124 (0.8%)	136 (0.8%)	**0.015**	1.647 (0.738–3.674), p value 0.223
Cardiac complications[f]	6 (0.2%)	176 (1.2%)	182 (1%)	**<0.0001**	0.614 (0.239–1.579), p value 0.312
VTE[g]	31 (1.1%)	244 (1.7%)	275 (1.6%)	**0.018**	0.616 (0.350–1.084), p value 0.093
LOS, median (IQR), days	4 (3–8)	4 (3–9)	4 (3–9)	0.015	
LOS >5 days (Q3)	871 (30%)	4,447 (30.4%)	5,318 (30.4%)	0.7	na
Unplanned readmission	285 (9.8%)	1,059 (7.2%)	1,344 (7.7%)	<0.0001	**1.393 (1.110–1.749), *p* value 0.004**
Mortality (within 30 days)	3 (0.1%)	163 (1.1%)	166 (0.9%)	<0.0001	**0.186 (0.048–0.723), *p* value 0.015**

CD, Crohn's disease; CC, colon cancer; VTE, vascular thromboembolism; SSI, surgical site infection; LOS, length of stay; UTI, urinary tract infection; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure. Figures in bold indicate statistical significance. [a] CC was used as a reference. Adjusted for age, gender, race, BMI, operative approach, diabetes mellitus, current smoker within 1 year, history of severe COPD, functional health status prior to surgery, CHF in 30 days before surgery, hypertension requiring medication, currently on dialysis (pre-op), steroid use for chronic condition, >10% loss body weight in last 6 months, transfusion ≥1 units in 72 h before surgery, ASA classification, total operation time, albumin <3.5 g/dL, hematocrit <35%, and platelets <150 k/mL. [b] Surgical complications include SSI, wound disruption, systemic sepsis, postoperative ileus, leak, unplanned reoperation, need for blood transfusion, and/or LOS >5 days. [c] Medical complications include UTI, respiratory complications, renal complications, cardiac complications, and/or VTE. [d] Respiratory complications include pneumonia, unplanned intubation, and/or on ventilator ≥48 h. [e] Renal complications include progressive renal insufficiency and/or acute kidney injury. [f] Cardiac complications include cardiac arrest requiring cardiopulmonary resuscitation and/or myocardial infarction. [g] VTE includes deep venous thrombosis and/or pulmonary embolism.

cations including respiratory, cardiovascular, and urinary complications (Table 2). Unplanned reoperation rates were comparable (3.8 vs. 3.6%, $p = 0.6$), while overall 30-day mortality was higher in cancer patients (1.1 vs. 0.1% in CD, $p < 0.001$). Median LOS was similar in both groups: 4 (IQR 3–8) days for CD and 4 (IQR 3–9) days for cancer patients ($p = 0.015$).

After risk adjustment, surgical complications, sepsis, and unplanned readmissions were higher in patients with CD. Cancer patients were more prone to septic shock, need for blood transfusion, and unplanned intubation and had a higher 30-day mortality (Table 2).

Disease-Specific Risk Factors

Independent unmodifiable risk factors for surgical complications in patients with CD were male gender, African American race, and ASA score, while the independent modifiable risk factors were active smoking and preoperative anemia. Independent unmodifiable risk factors for surgical complications in the cancer group were age

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Table 3. Risk factors for surgical complications

	CD				CC			
	no *n* = 1,805	yes *n* = 1,094	univariable *p* value	multivariable OR (95% CI)	no *n* = 8,844	yes *n* = 5,773	univariable *p* value	multivariable OR (95% CI)
Age categories, years								
<50	1,321 (73.1%)	740 (67.8%)	**0.008**	Reference	527 (5.9%)	251 (4.4%)	**<0.0001**	Reference
51–69	424 (23.5%)	300 (27.5%)		0.979 (0.803–1.193)	3,990 (45.1%)	1,904 (33.0%)		0.982 (0.827–1.166)
≥70	63 (3.5%)	51 (4.7%)		1.152 (0.757–1.752)	4,333 (48.9%)	3,612 (62.6%)		1.518 (1.275–1.808)
Gender, male	743 (41.1%)	533 (48.8%)	**<0.0001**	**1.308 (1.111–1.540)**	4,052 (45.8%)	2,833 (49.1%)	**<0.0001**	**1.196 (1.112–1.287)**
Race								
White	1,512 (83.6%)	869 (79.7%)	**0.007**	Reference	6,449 (72.9%)	3,970 (68.8%)	**<0.0001**	Reference
African American	136 (7.5%)	120 (11.0%)		**1.482 (1.123–1.956)**	840 (9.5%)	561 (9.7%)		1.077 (0.951–1.220)
Asian	15 (0.8%)	4 (0.4%)		0.414 (0.132–1.293)	260 (2.9%)	138 (2.4%)		1.025 (0.817–1.285)
Others	6 (0.3%)	2 (0.2%)		0.549 (0.106–2.851)	29 (0.3%)	27 (0.5%)		1.744 (0.991–3.068)
Unknown	139 (7.7%)	96 (8.8%)		1.144 (0.858–1.526)	1,272 (14.4%)	1,071 (18.6%)		**1.368 (1.239–1.511)**
BMI, kg/m^2								
Normal	816 (45.2%)	450 (41.2%)	0.247	na	2,414 (27.3%)	1,688 (29.3%)	**<0.0001**	Reference
Underweight	119 (6.6%)	84 (7.7%)		na	162 (1.8%)	125 (2.2%)		0.865 (0.648–1.155)
Overweight	497 (27.5%)	304 (27.9%)		na	3,081 (34.8%)	1,832 (31.8%)		**0.859 (0.783–0.943)**
Obese	372 (20.6%)	250 (22.9%)		na	3,158 (35.7%)	2,086 (36.2%)		0.919 (0.835–1.012)
Missing	4 (0.2%)	3 (0.3%)		na	35 (0.4%)	36 (0.6%)		Not included
Minimally invasive surgery	1,222 (67.5%)	517 (47.5%)	**<0.0001**	**0.477 (0.406–0.561)**	7,044 (79.6%)	3,223 (55.9%)	**<0.0001**	**0.343 (0.318–0.371)**
Diabetes mellitus	43 (2.4%)	27 (2.5%)	0.870	na	1,709 (19.3%)	1,353 (23.5%)	**<0.0001**	1.004 (0.916–1.100)
Current smoker	369 (20.4%)	266 (24.4%)	0.012	**1.260 (1.040–1.526)**	950 (10.7%)	721 (12.5%)	**0.001**	**1.277 (1.137–1.433)**
History of severe COPD	13 (0.7%)	19 (1.7%)	**0.011**	1.953 (0.918–4.156)	422 (4.8%)	533 (9.2%)	**<0.0001**	**1.560 (1.351–1.803)**
Functional health status								
Independent	1,800 (99.6%)	1,086 (99.5%)	0.938	na	8,698 (98.3%)	5,495 (95.3%)	**<0.0001**	Reference
Dependent	4 (0.2%)	3 (0.3%)		na	109 (1.2%)	228 (3.9%)		**2.180 (1.704–2.789)**
Missing	4 (0.2%)	2 (0.2%)		na	43 (0.5%)	44 (0.8%)		1.244 (0.788–1.964)
CHF within 30 days of surgery	2 (0.1%)	1 (0.1%)	0.878	na	50 (0.6%)	81 (1.4%)	**<0.0001**	1.269 (0.868–1.857)
Hypertension requiring medication	247 (13.7%)	202 (18.5%)	**<0.0001**	1.178 (0.931–1.490)	5,036 (56.9%)	3,727 (64.6%)	**<0.0001**	**1.121 (1.034–1.215)**
Hemodialysis	2 (0.1%)	2 (0.2%)	0.609	na	36 (0.4%)	34 (0.6%)	**0.072**	1.051 (0.637–1.736)
Chronic steroid use	1,063 (58.7%)	629 (57.8%)	0.546	na	267 (3.0%)	236 (4.1%)	**<0.0001**	1.173 (0.968–1.422)
Severe malnutrition, loss of body weight								
≥10%/6 months, and BMI <18.5 kg/m^2	44 (0.4%)	46 (0.7%)	**0.019**	1.342 (0.687–2.623)	22 (0.2%)	28 (0.5%)	**0.016**	1.410 (0.729–2.727)
PRBC transfusion within 72 h of surgery	2 (0.1%)	4 (0.4%)	0.142	na	70 (0.8%)	121 (2.1%)	**<0.0001**	**1.564 (1.133–2.160)**
ASA class (III or IV)	497 (27.4%)	416 (38.2%)	**<0.0001**	**1.350 (1.133–1.608)**	5,169 (58.4%)	4,184 (72.6%)	**<0.0001**	**1.354 (1.247–1.471)**
Operation time, minutes, median (IQR)	134 (102–172)	155 (114–205)	**<0.0001**	**1.005 (1.004–1.007)**	128 (96–167)	134 (99–179)	**<0.0001**	**1.003 (1.003–1.004)**
Preoperative albumin								
≥3.5 g/dL	942 (52.0%)	526 (48.4%)	**<0.0001**	Reference	4,932 (55.7%)	2,878 (49.9%)	**<0.0001**	Reference
<3.5 g/dL	328 (18.2%)	264 (24.1%)		1.130 (0.912–1.399)	1,255 (14.2%)	1,366 (23.7%)		**1.278 (1.158–1.411)**
Missing	538 (29.8%)	301 (27.5%)		1.024 (0.839–1.250)	2,663 (30.1%)	1,523 (26.5%)		0.968 (0.887–1.056)
Preoperative hematocrit								
≥35%	1,339 (74.1%)	760 (69.7%)	**0.001**	Reference	5,307 (60.0%)	2,694 (46.8%)	**<0.0001**	Reference
<35%	344 (19.0%)	271 (24.9%)		**1.420 (1.157–1.742)**	3,234 (36.6%)	2,941 (50.9%)		**1.534 (1.421–1.656)**
Missing	125 (6.9%)	60 (5.5%)		0.587 (0.269–1.282)	309 (3.5%)	132 (2.3%)		1.179 (0.781–1.780)
Preoperative platelet count								
≥150,000/mL	1,639 (90.6%)	984 (90.2%)	**0.04**	Reference	8,065 (91.1%)	5,250 (91.0%)	**<0.0001**	Reference
<150,000/mL	29 (1.6%)	32 (2.9%)		1.376 (0.799–2.368)	386 (4.4%)	345 (6.0%)		1.142 (0.972–1.341)
Missing	140 (7.8%)	75 (6.9%)		1.586 (0.766–3.283)	399 (4.5%)	172 (3.0%)		0.848 (0.588–1.221)

CD, Crohn's disease; CC, colon cancer; BMI, body mass index; COPD, chronic obstructive pulmonary disease; CHF, congestive heart failure; PRBC, packed red blood cells; ASA, American Society of Anesthesiologists. Figures in bold indicate statistical significance.

≥70 years, male gender, ASA score (III or IV), history of severe COPD, and dependent functional health status, while the independent modifiable risk factors were active smoking, hypertension requiring medication, blood transfusion within 72 h of surgery, and preoperative hypoalbuminemia (<3.5 g/dL). Minimally invasive surgery was protective in both groups, while prolonged surgery was associated with an increased risk of surgical complications (Table 3).

Discussion

The present study highlights important differences in patient characteristics and risk factors of CD and cancer patients undergoing right-sided elective surgery. Surgical and infectious complications were higher in the CD group as well as after risk adjustment for the baseline confounders. On the other hand, the cancer group experienced more medical complications and higher 30-day mortality. While smoking, high comorbidity index, open surgery, and male gender were identified as risk factors for surgical complications in both conditions, this study emphasizes the importance of proper conditioning of patients with CD by addressing preoperative anemia. Respiratory/cardiovascular comorbidities and functional dependence combined with malnutrition were identified as major predictors of adverse outcomes in the older cancer cohort. Correcting the modifiable deficits, when feasible, likely contributes to better short-term surgical outcomes.

Right colectomy for cancer is a standardized procedure carried out by most general surgeons [10]. Because of the preponderance of terminal ileal disease and a 10-year risk of surgical resection of almost 50%, many patients with CD eventually require ileocolonic resections [11, 12]. Because of the complexity of medical management requiring thorough surveillance and follow-up, patients with CD are treated in dedicated inflammatory bowel disease units [13]. ACS-NSQIP does not discriminate between specific settings or case volume of contributing centers and disposes of a limited amount of disease-specific variables. However, the dataset yields a 20% representative sample of the US surgical population [14]. Thus, considering the large scale of this study, a risk-adjusted comparative analysis may help to better understand disease-specific risk factors and outcomes when comparing right-sided colon resections in both conditions.

Overall, postoperative morbidity compared well to previous reports from other large data registries for both disease categories [15–17]. However, national data analyses bear a risk of skewing outcomes due to underreporting and missing data, which needs to be strongly considered for this present comparative analysis [18]. With 5.3%, the rate of clinically relevant organ-space infections in the CD group was significantly higher than in the cancer cohort (2.9%). This may, together with the increased rate of postoperative sepsis in patients with CD, reflect both immunosuppression and complicated disease states. This finding is in line with previous literature describing an increased risk of CD-associated postoperative infectious complications, especially in the setting of hypoalbuminemia and steroid use [19, 20]. Collectively, this highlights the importance of the surgical decision-making process regarding restoration of gastrointestinal continuity at index surgery versus the creation of an ileostomy. Of note, the slightly higher rate of septic shock in the cancer group despite a lower occurrence of sepsis is likely related to age-related impaired physiologic tolerance of sepsis in this population [21]. The older cancer cohort, presenting with more age-related comorbidities, was prone to both medical complications and increased 30-day mortality. Functional recovery (mobilization and alimentation) was likely accelerated in the younger CD population, which may have further contributed to decreased medical complications [12]. While LOS was similar in both groups (70% discharged within 5 days), (risk-adjusted) readmissions were higher in patients with CD. The increased 30-day mortality in the significantly older cancer cohort represents an expected finding.

The main purpose of this study was to identify disease-specific risk factors for CD and cancer to identify potentially modifiable risk factors. The findings support the importance of preoperative optimization of patients with CD including smoking cessation, correction of anemia, nutritional deficiencies, and electrolyte abnormalities in the elective setting [22, 23]. This is even more important in the light of prevailing deep infections and septic complications after CD surgery, confirming the beneficial impact of preoperative optimization [24–26]. Our analysis further suggests that prehabilitation strategies may be beneficial in cancer patients with particular focus on smoking cessation and respiratory conditioning to mitigate risks related to general anesthesia and to promote postoperative recovery [27]. Furthermore, best possible control of cardiovascular risk factors such as hypertension and anemia may help to further improve surgical outcomes [28, 29]. Of note, the higher incidence of surgical complications in African American patients has been previously observed and may be related to differences in

socioeconomic status, access to health care, and thus an increased risk of complicated disease presentations in these patients [30].

It is important to mention that preoperative optimization can be challenging in both patients with CD and patients with CC. Patients with CD are usually chronically immune suppressed, and the main surgical indication is typically medically refractory, complicated disease. Hence, delaying surgery to account for preoperative risk factors may be associated with disease progression and worse outcomes [31]. On the other side, patients with CC are usually older and present with multiple comorbidities, and significantly delaying surgical resection of primary cancer may be associated with worse survival outcomes [32, 33].

This study has limitations beyond its retrospective design and limitations related to ACS-NSQIP in general. Details about both previous and preoperative CD management are lacking and impede further analysis of safety profiles beyond chronic steroid use as a surrogate for disease severity. This represents a significant limitation given the potential impact according to type, number, timing, and duration of previous or ongoing medical CD therapy on postoperative short-term outcomes. The data pool is heterogeneous, and specifics on perioperative care, caseload, and institutional settings are lacking. The ACS-NSQIP® definition for elective surgery (coming from home) may not be entirely representative of actual disease severity in patients with CD, despite independent preoperative functional health status in most patients. The large, representative dataset and the focus on a single, frequently performed procedure may help to alleviate some of these shortcomings.

Conclusions

Patients with CD were more prone to surgical complications and postoperative sepsis compared to the cancer group undergoing right-sided resections. Careful evaluation and correction of disease-specific modifiable risk factors of both CD and cancer patients when possible are important to reduce postoperative morbidity.

Statement of Ethics

No ethical approval was needed as this study utilized a national database with no attempt to identify the patients.

Conflict of Interest Statement

There are no conflicts of interest to declare.

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Author Contributions

F.G., M.A.A., W.P., K.T.B., S.S., K.L.M., and D.W.L: conception and design, analysis and interpretation of data, and drafting of the manuscript. M.A.A. and F.G.: acquisition of data. All authors were involved in critical revision of the manuscript and final approval of the version to be published.

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