

Risk of Comorbidities on Postoperative Outcomes in Patients With Inflammatory Bowel Disease

Gilaad G. Kaplan, MD, MPH, FRCPC; James Hubbard, MSc; Remo Panaccione, MD; Abdel Aziz M. Shaheen, MD, MPH; Hude Quan, PhD; Geoffrey C. Nguyen, MD, PhD; Elijah Dixon, MD, MSc; Subrata Ghosh, MD; Robert P. Myers, MD, MSc

Background: The effect of comorbidities on postoperative outcomes in patients with inflammatory bowel disease (IBD) has not been explored adequately. We evaluated the prevalence of comorbidities and their effect on postoperative outcomes after an IBD-related operation.

Methods: The Nationwide Inpatient Sample database was used to identify 35 588 patients with IBD who underwent an IBD-related operation from January 1, 1995, through December 31, 2005. The presence of comorbid illness was assessed using the Elixhauser index. Multiple logistic regression analysis was performed to evaluate the effect of comorbidities on mortality rate after adjusting for age, sex, race, health insurance status, and admission type. Linear regression models were used to evaluate health care resource use.

Results: Postoperative mortality was 1.9%. As the number of comorbidities increased (ie, 0, 1, 2, or ≥ 3), postoperative mortality increased (0.4%, 1.5%, 3.3%, and 7.9%, respectively). Congestive heart failure (odds ratio, 3.50 [95% confidence interval, 2.63-4.62]), liver disease (3.15 [2.00-4.97]), thromboembolic disease (4.19 [3.37-5.21]), and renal disease (8.74 [5.44-14.05]) were associated with a significant increase in mortality rate. Comorbidities associated with an increased risk of mortality also were associated with a significant increase in length of stay and hospital charges.

Conclusions: Comorbidities were common in patients with IBD and they significantly increased the risk of postoperative mortality and health care use in patients with IBD.

Arch Surg. 2011;146(8):959-964

Author Affiliations:

Inflammatory Bowel Disease Clinic (Drs Kaplan, Panaccione, and Ghosh and Mr Hubbard), and Departments of Medicine (Drs Kaplan, Panaccione, Shaheen, Ghosh, and Myers and Mr Hubbard), Community Health Sciences (Drs Kaplan, Quan, and Dixon), and Surgery (Dr Dixon), University of Calgary, Alberta; and Mount Sinai Hospital, University of Toronto School of Medicine, Ontario (Dr Nguyen), Canada. Dr Kaplan is now with the Teaching Research and Wellness Center, Calgary, Alberta, Canada.

PATIENTS HOSPITALIZED FOR AN inflammatory bowel disease (IBD) flare-up are commonly prescribed intravenous corticosteroids, and those for whom medical management is unsuccessful typically undergo surgery.¹ An IBD-related operation is technically complex, and the patients are often systemically unhealthy and receiving immunosuppressive medications. Consequently, patients undergoing an IBD-related bowel operation may experience postoperative morbidity, including death.^{2,3} Factors shown to influence postoperative outcomes include age, health insurance status, emergency operations, surgical experience, and comorbidities.^{2,4,5}

See Invited Critique at end of article

Elderly patients with IBD have been shown to have significantly worse postoperative outcomes.⁶ Presumably, the worse outcomes are associated with underlying comorbidities in elderly patients, such as cardiovascular disease. How-

ever, patients with IBD represent a unique surgical population because young patients with IBD are at increased risk for comorbidities, such as thromboembolic disease. The prevalence of common comorbidities (eg, diabetes mellitus), as well as IBD-specific comorbidities (eg, primary sclerosing cholangitis), have not been explored in patients with IBD undergoing bowel resection. Moreover, the effect of specific comorbidities on postoperative outcomes in a population with IBD has not been established. Therefore, we studied a nationally representative cohort of patients with IBD who underwent an IBD-related operation to assess the prevalence and effect of preoperative comorbidity status on postoperative mortality rate and health care resource use.

METHODS

DATA SOURCE

All data were extracted from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS) database for January 1, 1995, through December 31, 2005. The NIS is the largest all-payer database of national hospital

Table 1. Characteristics of Patients With IBD Undergoing an IBD-Related Operation From January 1, 1995, Through December 31, 2005

Characteristic	Value
Age, median (IQR), y	42 (31-56)
Length of stay, median (IQR), d ^a	8 (6-12)
Total hospital charges, median (IQR), \$ ^{a,b}	29 150 (19 913-45 869)
Died in the hospital, %	1.9
Race, %	
White	63.7
African American	4.9
Hispanic	2.0
Other/unknown	29.4
Male sex, %	48.2
Emergency admission, %	24.8
Health insurance coverage status, %	
Private	69.3
Medicare	16.1
Medicaid	7.0
Other/unknown	7.6
IBD type, %	
Crohn disease	67.3
Ulcerative colitis	32.7

Abbreviations: IBD, inflammatory bowel disease; IQR, interquartile range.

^aMissing data: length of stay (n=5); hospital charges (n=420).

^bTotal charges were adjusted for inflation.

discharges (recording data regarding approximately 8 million discharges per year) maintained by the Agency for Healthcare Research and Quality. The NIS contains a stratified sample (ie, approximately 20.0%) of hospital discharge abstracts from non-federal acute care hospitals in the United States, including community, general, and academic centers, but excludes long-term care facilities. Stratified random sampling is performed to ensure that the database content is representative of the US population and that it accounts for approximately 90.0% of all hospitalizations. Each discharge abstract includes a scrambled patient identifier, demographic data, hospital transfer status, admission type (ie, emergency or elective), primary and secondary diagnoses (as many as 15), procedures (as many as 15), health insurance status, hospital charges, and length of stay. The NIS contains information regarding diagnostic and procedure codes based on the *International Classification of Diseases, 9th Version, Clinical Modification (ICD-9-CM)*.⁷ Because each record in the NIS is coded per hospitalization rather than per individual, multiple records for an individual may exist. Quality control and validation of the NIS is performed by the Agency for Healthcare Research and Quality.⁸⁻¹³ The NIS data also compare favorably with those of the National Hospital Discharge Survey, supporting the validity of this database.⁸⁻¹³

STUDY POPULATION

The *ICD-9-CM* diagnosis codes (primary or secondary) were used to identify 41 564 discharges of patients with ulcerative colitis (556.0) or Crohn disease (555.0) aged 18 to 80 years who had undergone an IBD-related operation (eAppendix 1: *ICD-9 Codes for IBD-Related Operations*¹⁴; <http://www.archsurg.com>) from January 1, 1995, through December 31, 2005. We excluded patients who lacked data regarding in-hospital death (n=31). Also, patients transferred to other institutions were excluded (n=2260) because in-hospital mortality rate, our primary outcome measure, was unavailable in these patients. Patients also were excluded if they lacked data regarding admission type (emergency vs urgent/elective; n=3683) and sex (n=2).

The final sample consisted of 35 588 discharges of patients with IBD who had undergone an IBD-related operation.

STUDY VARIABLES

The primary outcome of interest was in-hospital mortality. The secondary outcome was health resource use as defined by length of stay and total hospital charges adjusted for inflation to 2005 dollars using the US Consumer Price Index for medical care.²

Covariates included patient age; sex; IBD type, defined as Crohn disease vs ulcerative colitis; health insurance status, classified as private, Medicare, Medicaid, or other/unknown; race and ethnicity, categorized as white, African American, Hispanic, or other/unknown; and admission type, defined as emergency vs elective or urgent admission.

COMORBIDITY MEASURES

We studied the Elixhauser comorbidity algorithm, which is a commonly used risk adjustment measure derived from the hospital discharge abstract. The Elixhauser comorbidity algorithm has been validated in the population with IBD.¹⁶ The Elixhauser algorithm is nonproprietary and routinely can be applied to administrative data using widely available computer algorithms. The Elixhauser index uses *ICD-9-CM* diagnosis codes to identify 30 categories of comorbidities (eAppendix 2).¹⁵ The Elixhauser method employs a diagnosis-related group restriction that eliminates conditions directly related to the primary reason for hospitalization.¹⁵ Accordingly, a secondary diagnosis (eg, congestive heart failure) related to the primary diagnosis (eg, myocardial infarction) via a specific diagnosis-related group category is considered a modifier of this diagnosis and an indicator of illness severity rather than a comorbidity. In a secondary analysis, we specifically evaluated comorbidities that have been shown to occur in higher prevalence among patients with IBD, including primary sclerosing cholangitis,¹⁷ myocardial infarction,¹⁸ ischemic stroke,¹⁸ thrombosis or embolism,¹⁹ rheumatoid arthritis,²⁰ colon cancer,²¹ multiple sclerosis,²⁰ ankylosing spondylitis,²⁰ and asthma.²⁰ (eAppendix 2).

STATISTICAL ANALYSIS

Logistic regression analyses were used to assess the contributions of the individual Elixhauser comorbidities to predicted in-hospital mortality rate. Each regression model contained a set of independent variables adjusting for sociodemographic and clinical differences between patients, including age, sex, health insurance type (ie, private, Medicaid, Medicare, or other/unknown), race (ie, white, African American, Hispanic, or other/unknown), and emergency admission (ie, emergency vs urgent and elective combined). In a secondary analysis, we evaluated the effect of IBD-specific comorbidities (ie, primary sclerosing cholangitis, myocardial infarction, ischemic stroke, thrombosis/embolism, multiple sclerosis, rheumatoid arthritis, ankylosing spondylitis, colon cancer, and asthma) on in-hospital mortality. Linear regression models determined the effect of Elixhauser comorbidities on health care resource use, defined as length of stay and hospital charges, which were logarithmically transformed because of their skewed distributions. We present antilogarithms of the coefficients from these models to reflect the percentage change in resource use from having a particular comorbidity independent of other patient characteristics.

For postoperative mortality rate and health care resource use, we also categorized both comorbidity indices as 0, 1, 2, or 3 or more present, as commonly performed in the literature.^{10,22} For the categorized comorbidities, we described the

Table 2. Elixhauser Comorbidities: Prevalence and Relationship to In-Hospital Mortality Rate, Length of Stay, and Hospital Charges for 35 588 Patients With IBD

Comorbidity	Prevalence, No. (%)	In-Hospital Mortality Odds Ratio (95% CI) ^a	LOS Transformed Coefficient (95% CI) ^{a,b}	Hospital Charges Transformed Coefficient (95% CI) ^{a,b}
Congestive heart failure	517 (1.45)	3.50 (2.63-4.62)	1.30 (1.24-1.36)	1.41 (1.33-1.49)
Cardiac arrhythmias	1447 (4.07)	2.29 (1.81-2.90)	1.14 (1.11-1.17)	1.27 (1.23-1.32)
Valvular disease	698 (1.96)	0.69 (0.44-1.11)	1.01 (0.97-1.05)	1.01 (0.96-1.05)
Hypertension	4629 (13.01)	0.55 (0.43-0.69)	0.96 (0.94-0.97)	0.97 (0.95-0.99)
Pulmonary circulation disorders	38 (0.11)	1.16 (0.32-4.17)	0.97 (0.82-1.14)	1.08 (0.89-1.31)
Peripheral vascular disorders	311 (0.87)	2.33 (1.50-3.62)	0.98 (0.93-1.04)	1.02 (0.95-1.09)
Paralysis	82 (0.23)	2.12 (0.94-4.78)	1.09 (0.97-1.22)	0.99 (0.86-1.13)
Other neurological disorders	492 (1.38)	1.69 (1.04-2.75)	1.21 (1.15-1.26)	1.23 (1.16-1.30)
Chronic pulmonary disease	2563 (7.20)	1.08 (0.85-1.38)	1.01 (0.99-1.03)	1.07 (1.04-1.10)
Diabetes mellitus, uncomplicated	1462 (4.11)	1.00 (0.73-1.38)	1.01 (0.98-1.04)	1.06 (1.03-1.10)
Diabetes mellitus, complicated	128 (0.36)	1.46 (0.71-2.99)	1.16 (1.06-1.28)	1.16 (1.04-1.29)
Hypothyroidism	932 (2.62)	0.39 (0.22-0.70)	0.96 (0.92-0.99)	0.96 (0.93-1.00)
Renal failure	149 (0.42)	8.74 (5.44-14.05)	1.19 (1.10-1.30)	1.55 (1.40-1.71)
Liver disease	436 (1.23)	3.15 (2.00-4.97)	1.09 (1.04-1.15)	1.26 (1.19-1.34)
Peptic ulcer disease (with no bleeding)	29 (0.08)	0.99 (0.09-10.51)	1.02 (0.84-1.24)	1.08 (0.87-1.36)
AIDS	18 (0.05)	3.52 (0.40-30.59)	0.84 (0.66-1.07)	1.00 (0.76-1.33)
Lymphoma	68 (0.19)	0.98 (0.31-3.04)	1.06 (0.94-1.20)	1.03 (0.90-1.20)
Metastatic cancer	797 (2.24)	1.19 (0.77-1.84)	1.08 (1.04-1.12)	1.08 (1.04-1.13)
Solid tumor without metastasis	343 (0.96)	0.77 (0.38-1.60)	1.05 (1.00-1.12)	1.15 (1.08-1.23)
Rheumatoid arthritis/collagen vascular diseases	396 (1.11)	1.40 (0.73-2.68)	1.07 (1.02-1.13)	1.08 (1.02-1.15)
Coagulopathy	537 (1.51)	12.08 (9.18-15.90)	1.37 (1.31-1.43)	1.85 (1.76-1.95)
Obesity	746 (2.10)	0.47 (0.18-1.21)	1.01 (0.97-1.04)	1.04 (1.00-1.09)
Weight loss	2651 (7.45)	1.71 (1.34-2.17)	1.55 (1.52-1.59)	1.54 (1.50-1.58)
Fluid and electrolyte disorders	6213 (17.46)	2.01 (1.67-2.41)	1.31 (1.29-1.33)	1.32 (1.30-1.34)
Blood loss-related anemia	1172 (3.29)	0.78 (0.52-1.16)	1.24 (1.20-1.28)	1.22 (1.17-1.26)
Iron deficiency-related anemia	4049 (11.38)	0.40 (0.28-0.56)	1.11 (1.09-1.13)	1.12 (1.10-1.15)
Alcohol abuse	211 (0.59)	0.96 (0.40-2.34)	1.11 (1.03-1.19)	1.08 (0.99-1.17)
Drug abuse	265 (0.74)	0.70 (0.22-2.22)	1.31 (1.23-1.40)	1.24 (1.15-1.34)
Psychoses	348 (0.98)	1.64 (0.85-3.14)	1.22 (1.16-1.29)	1.20 (1.12-1.28)
Clinical depression	1390 (3.91)	0.69 (0.39-1.21)	1.14 (1.11-1.17)	1.11 (1.08-1.15)

Abbreviations: CI, confidence interval; IBD, inflammatory bowel disease; LOS, length of stay.

^aAll models were adjusted for age, sex, race, primary health insurer, emergency admission, and the comorbidities.

^bAntilogarithms of coefficients from multivariate linear regression analyses of the logarithm of the independent variables.

prevalence and the corresponding in-hospital mortality and health care resource use. Finally, the probability of postoperative death was stratified according to admission type (ie, emergency vs elective), age (ie, 18-34, 35-64, or 65-80 years), and number of comorbidities (ie, 0-1 vs ≥ 2 comorbidities). Statistical analyses were performed using SAS statistical software, version 9.1.3 (SAS Institute Inc, Cary, North Carolina).

RESULTS

From January 1, 1995, through December 31, 2005, we identified 35 588 patients with IBD (67.3% of whom had Crohn disease) who underwent an IBD-related operation in sampled US hospitals. The median age of the cohort was 42 years, 48.2% were men, 63.7% were white, and 69.3% had private health insurance coverage. One-quarter of IBD patients were admitted on an emergency basis before their operation. Overall, in-hospital mortality was 1.9%, the median length of stay was 8 days, and the median total hospital charges were \$29 150 (**Table 1**).

Table 2 demonstrates the adjusted effect of each individual comorbidity on postoperative mortality rate and health care resource use (ie, length of stay and hospital charges). Cardiovascular disease (eg, congestive heart failure: odds ratio [OR], 3.50 [95% confidence interval {CI},

2.63-4.62]), cardiac arrhythmias (2.29 [1.81-2.90]), liver disease (3.15 [2.00-4.97]), and renal failure (Elixhauser: 8.74 [5.44-14.05]) were prevalent comorbidities associated with a significant increase in mortality rate. Mostly, comorbidities associated with an increased risk of mortality also were associated with a significant increase in length of stay and hospital charges. Coagulopathy and fluid and electrolyte disorders were prevalent and they significantly influenced postoperative mortality rate and health care resource use (**Table 2**). Hypertension and hypothyroidism were negatively associated with postoperative mortality rate, length of stay, and total charges (**Table 2**). Patients with a history of thrombosis or embolism were at increased risk for postoperative mortality (OR, 4.19 [95% CI, 3.37-5.21]). Although patients coded with lymphoma or solid tumor malignancy were not at increased risk of postoperative death, patients with IBD who had colorectal cancer were at reduced risk of death (OR, 0.43 [95% CI, 0.25-0.71]) (**Table 3**).

Mortality rate, length of stay, and total hospital charges increased as the number of comorbidities in patients with IBD rose from 0 to 1, to 2, and to 3 or more. Although only a small proportion of patients with IBD (10.0%) had

3 or more Elixhauser comorbidities, the mortality was considerable (7.9%) in these patients (**Table 4**). Elderly patients undergoing emergency surgery with multiple comorbidities had considerably higher mortality (20.6%) compared with that of young adults without multiple comorbidities undergoing an elective operation (0.1%) (**Figure**).

COMMENT

Patients with IBD are distinctly different from general preoperative patients. Patients with IBD are typically systemically unhealthy and are receiving immunosuppressing medications, such as corticosteroids. The patients with IBD undergoing an operation are often younger; although they may have fewer comorbidities, patients with IBD are at increased risk for specific IBD complications, such as thromboembolic disease.^{3,23} Consequently, risk adjustment tools such as the Elixhauser¹⁵ index have been applied routinely to studies using administrative databases to assess postoperative outcomes in a population with IBD.^{2,24} This article confirms that risk adjustment of comorbidities is necessary because comorbidities were prevalent in the population with IBD and because the presence of comorbidities was associated with a high risk of postoperative death and health care resource use.

We described the associations between various comorbid conditions and outcomes (ie, mortality rate and health care resource use) in a cohort of patients who had undergone an IBD-related operation. The

most prevalent and strongest predictors of mortality rate were cardiovascular disease, liver disease, and renal disease. Risk adjustment for comorbidities commonly has been applied to patients with IBD^{2,24,25}; however, prior studies have not evaluated the effect of individual comorbidities (eg, liver disease) on postoperative outcomes. Although many patients with IBD receive the diagnosis in their youth, the median age of operation in our study population was 42 years. In addition, more than 25% of patients with IBD were operated on when older than 55 years, when comorbidities often are present. Furthermore, patients with IBD are at higher risk of developing comorbid conditions at a younger age, including liver disease (eg, primary sclerosing cholangitis)²⁶ and coronary artery disease.¹⁸ Thus, irrespective of patient age, pre-existing illnesses are important considerations before operating on a patient with IBD.

In contrast, hypothyroidism and hypertension were negatively associated with postoperative mortality rate and health care resource use. The protective effects observed may have resulted from the inverse relationship between disease severity and coding of certain common and singly unthreatening disorders (eg, hypertension).^{15,27-29} Also, patients with a history of colon cancer were less likely to die after their operation. Most patients with IBD diagnosed with colon cancer are operated on when their IBD is in remission. Thus, the protective effect observed may have been explained by mild disease activity at the time of surgery.

Moreover, we demonstrated a steady rise in mortality and health care resource use as the number of comorbidities increased among patients with IBD. The patients with IBD who had 3 or more comorbidities represented 10.0% of the study population; however, these patients experienced significant postoperative mortality (7.9%) compared with that of patients with 0 comorbidities (0.4%). Furthermore, among patients with multiple comorbidities, the probability of death was dependent on the setting of the operation and the age of the patient (Figure). In young adults (ie, aged 18-34 years), mortality rate was low, irrespective of admission type and comorbidity status. Patients undergoing colectomy after an emergency admission were at considerably increased risk of mortality, particularly in older patients with multiple comorbidities. These data can assist physicians and surgeons who are balancing the risks and benefits of surgical vs medical management. Those patients

Table 3. The Effect of IBD-Specific Comorbidities on In-Hospital Mortality

IBD-Specific Comorbidity	In-Hospital Mortality, Odds Ratio (95% CI) ^a
Thrombosis/embolism	4.19 (3.37-5.21)
Myocardial infarction	2.41 (1.69-3.45)
Multiple sclerosis	3.54 (1.02-12.36)
Rheumatoid arthritis	1.06 (0.44-2.56)
Colon cancer	0.43 (0.25-0.71)
Asthma	0.47 (0.26-0.86)

Abbreviations: CI, confidence interval; IBD, inflammatory bowel disease.

^aAll models were adjusted for age, sex, race, primary health insurer, emergency admission, and the comorbidities. Primary sclerosing cholangitis, ankylosing spondylitis, and ischemic stroke were not included in the model because patients with these comorbidities did not die.

Table 4. Relationship Between the Number of Elixhauser Comorbidities and Outcomes for 35 588 Patients With IBD^a

Characteristic	No. of Elixhauser Comorbidities			
	0	1	2	≥3
Patients, No. (%)	16 589 (46.6)	10 077 (28.3)	5372 (15.1)	3550 (10.0)
Age, y	37 (29-48)	44 (33-57)	50 (37-63)	58 (44-69)
Length of stay, d	7 (5-9)	8 (6-12)	10 (7-15)	12 (8-19)
Hospital charges, \$	24 598 (17 684-35 662)	30 638 (21 039-47 609)	37 538 (24 830-60 157)	46 466 (28 898-77 036)
In-hospital mortality, No. (%)	62/16 589 (0.4)	148/10 077 (1.5)	179/5372 (3.3)	282/3550 (7.9)

Abbreviation: IBD, inflammatory bowel disease.

^aData are given as median (interquartile range) unless otherwise indicated.

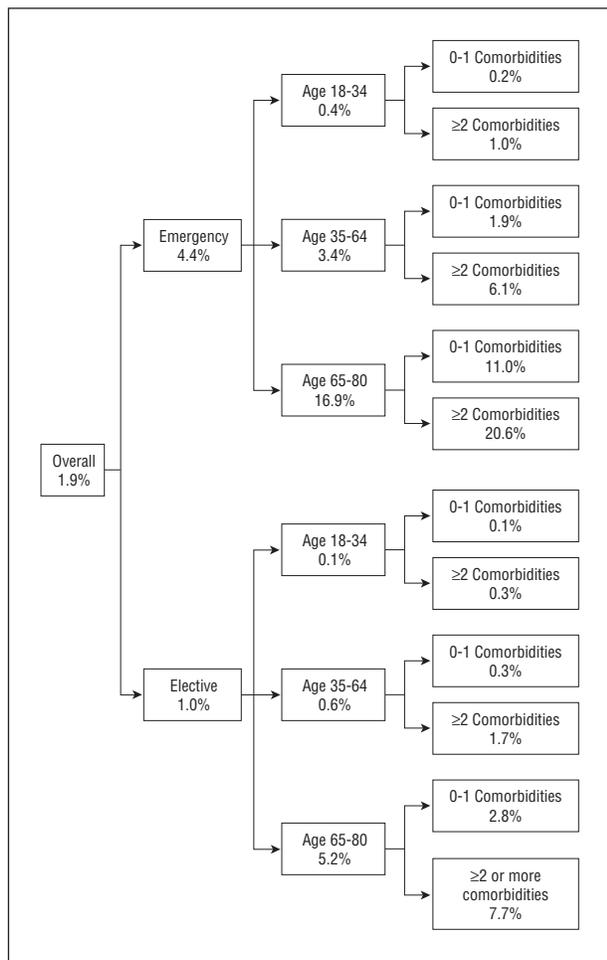


Figure. Probability of postoperative death stratified by admission type, age, and number of comorbidities.

with IBD who have multiple comorbidities should be reviewed by a gastroenterologist and a colorectal surgeon to evaluate the appropriate timing of an operation and to ensure optimization of medical management.³⁰ Postoperative outcomes may be improved by instituting standards of practice for preoperative assessment of patients with IBD, as used in other high-risk groups.³¹ This may include involvement of a general internist for preoperative risk stratification and optimization of detection of comorbidities.

Several limitations were inherent to the study. In all studies of administrative databases, misclassification is possible. However, in-hospital mortality is a robust outcome, and in-hospital coding of IBD previously has been validated.³² Length of stay and total hospital charges may not have been a reliable outcome measure of health care resource use because clinical practice and charges may differ between hospitals and across different regions. However, length of stay and hospital charges mostly correlated with postoperative mortality rate outcomes. The NIS database does not differentiate baseline comorbidities from in-hospital complications, which may lead to overadjustment in outcome analyses.^{33,34} For example, coagulopathy and fluid and electrolyte disorders were important predictors of worse outcomes, although in some patients with IBD, these

conditions may have occurred de novo in the hospital rather than being present at admission. However, empirical work using data with a diagnosis-type indicator that flags conditions present at admission has demonstrated that most common diagnoses are, in fact, comorbidities rather than complications.^{33,34} Also, we were not able to adjust for the effects of preoperative complications (eg, perforation or sepsis). In addition, because the NIS database is publicly available, all identifiable data are stripped; consequently, validation through cross-referencing the medical chart is impossible. However, validation of the NIS database is routinely and thoroughly performed by the Agency for Healthcare Research and Quality.³⁵ Furthermore, prescription data are not available in the NIS, and thus, we could not control for the use of in-hospital medications (eg, corticosteroids). The NIS database extracts data from discharge abstracts, which prevents investigators from following patient outcomes after discharge. Also, repeat admissions cannot be differentiated in the NIS database, and thus, within-patient correlations are possible. Finally, the NIS database defines admission type (ie, elective vs emergency operation); however, the database does not identify an emergency operation.

In conclusion, our results suggest that preoperative comorbidities are common and are associated with increased risk of mortality and health care resource use after an IBD-related operation. Thus, risk adjustment is necessary when studying postoperative analyses in patients with IBD. Finally, these data will serve physicians in risk stratification before performing operations on patients with IBD.

Accepted for Publication: July 19, 2010.

Correspondence: Gilaad G. Kaplan, MD, MPH, FRCPC, Teaching Research and Wellness Center, 3280 Hospital Dr NW, 6D17, Calgary, AB T2N 4N1, Canada (gkaplan@ucalgary.ca).

Author Contributions: *Study concept and design:* Kaplan, Shaheen, Nguyen, Dixon, and Myers. *Acquisition of data:* Kaplan. *Analysis and interpretation of data:* Kaplan, Hubbard, Panaccione, Quan, Ghosh, and Myers. *Drafting of the manuscript:* Kaplan, Hubbard, and Ghosh. *Critical revision of the manuscript for important intellectual content:* Kaplan, Hubbard, Panaccione, Shaheen, Quan, Nguyen, Dixon, and Myers. *Statistical analysis:* Kaplan, Hubbard, Shaheen, Nguyen, Dixon, and Myers. *Administrative, technical, and material support:* Kaplan. *Study supervision:* Kaplan, Panaccione, and Ghosh.

Financial Disclosure: None reported.

Funding/Support: This study was supported by grant 848 from the Medical Services Incorporation Foundation, a New Investigator Award from the Canadian Institute of Health Research (Dr Kaplan), and a Population Health Investigator Award from the Alberta Heritage Foundation for Medical Research (Dr Kaplan).

REFERENCES

- Podolsky DK. Inflammatory bowel disease. *N Engl J Med.* 2002;347(6):417-429.
- Kaplan GG, McCarthy EP, Ayanian JZ, Korzenik J, Hodin R, Sands BE. Impact of

- hospital volume on postoperative morbidity and mortality following a colectomy for ulcerative colitis. *Gastroenterology*. 2008;134(3):680-687.
3. Fichera A, Michelassi F. Surgical treatment of Crohn's disease. *J Gastrointest Surg*. 2007;11(6):791-803.
 4. Lesperance K, Martin MJ, Lehmann R, Brounts L, Steele SR. National trends and outcomes for the surgical therapy of ileocolonic Crohn's disease: a population-based analysis of laparoscopic vs open approaches. *J Gastrointest Surg*. 2009;13(7):1251-1259.
 5. Ananthakrishnan AN, McGinley EL, Binion DG. Does it matter where you are hospitalized for inflammatory bowel disease? a nationwide analysis of hospital volume. *Am J Gastroenterol*. 2008;103(11):2789-2798.
 6. Ananthakrishnan AN, McGinley EL, Binion DG. Inflammatory bowel disease in the elderly is associated with worse outcomes: a national study of hospitalizations. *Inflamm Bowel Dis*. 2009;15(2):182-189.
 7. World Health Organization. *International Classification of Diseases, 9th Version, Clinical Modification (ICD-9-CM)*. Geneva, Switzerland: World Health Organization 1998.
 8. Nguyen GC, Segev DL, Thuluvath PJ. Racial disparities in the management of hospitalized patients with cirrhosis and complications of portal hypertension: a national study. *Hepatology*. 2007;45(5):1282-1289.
 9. El-Serag HB, Everhart JE. Improved survival after variceal hemorrhage over an 11-year period in the Department of Veterans Affairs. *Am J Gastroenterol*. 2000;95(12):3566-3573.
 10. Dixon E, Schneeweiss S, Pasioka JL, Bathe OF, Sutherland F, Doig C. Mortality following liver resection in US Medicare patients: does the presence of a liver transplant program affect outcome? *J Surg Oncol*. 2007;95(3):194-200.
 11. Edwards EB, Roberts JP, McBride MA, Schulak JA, Hunsicker LG. The effect of the volume of procedures at transplantation centers on mortality after liver transplantation. *N Engl J Med*. 1999;341(27):2049-2053.
 12. Dy SM, Cromwell DM, Thuluvath PJ, Bass EB. Hospital experience and outcomes for esophageal variceal bleeding. *Int J Qual Health Care*. 2003;15(2):139-146.
 13. Glasgow RE, Showstack JA, Katz PP, Corvera CU, Warren RS, Mulvihill SJ. The relationship between hospital volume and outcomes of hepatic resection for hepatocellular carcinoma. *Arch Surg*. 1999;134(1):30-35.
 14. Bewtra M, Su C, Lewis JD. Trends in hospitalization rates for inflammatory bowel disease in the United States. *Clin Gastroenterol Hepatol*. 2007;5(5):597-601.
 15. Elixhauser A, Steiner C, Harris DR, Coffey RM. Comorbidity measures for use with administrative data. *Med Care*. 1998;36(1):8-27.
 16. Kaplan GG, Hubbard J, Panaccione R, et al. Predicting mortality from comorbidity indices in administrative databases among inflammatory bowel disease patients. *Am J Gastroenterol*. 2008;103(S1):285.
 17. Kaplan GG, Laupland KB, Butzner D, Urbanski SJ, Lee SS. The burden of large and small duct primary sclerosing cholangitis in adults and children: a population-based analysis. *Am J Gastroenterol*. 2007;102(5):1042-1049.
 18. Bernstein CN, Wajda A, Blanchard JF. The incidence of arterial thromboembolic diseases in inflammatory bowel disease: a population-based study. *Clin Gastroenterol Hepatol*. 2008;6(1):41-45.
 19. Bernstein CN, Blanchard JF, Houston DS, Wajda A. The incidence of deep venous thrombosis and pulmonary embolism among patients with inflammatory bowel disease: a population-based cohort study. *Thromb Haemost*. 2001;85(3):430-434.
 20. Bernstein CN, Wajda A, Blanchard JF. The clustering of other chronic inflammatory diseases in inflammatory bowel disease: a population-based study. *Gastroenterology*. 2005;129(3):827-836.
 21. Bernstein CN, Blanchard JF, Kiewer E, Wajda A. Cancer risk in patients with inflammatory bowel disease: a population-based study. *Cancer*. 2001;91(4):854-862.
 22. Thombs BD, Singh VA, Halonen J, Diallo A, Milner SM. The effects of preexisting medical comorbidities on mortality and length of hospital stay in acute burn injury: evidence from a national sample of 31,338 adult patients. *Ann Surg*. 2007;245(4):629-634.
 23. Kaplan GG, Gregson DB, Laupland KB. Population-based study of the epidemiology of and the risk factors for pyogenic liver abscess. *Clin Gastroenterol Hepatol*. 2004;2(11):1032-1038.
 24. Nguyen GC, Steinhardt AH. Nationwide patterns of hospitalizations to centers with high volume of admissions for inflammatory bowel disease and their impact on mortality. *Inflamm Bowel Dis*. 2008;14(12):1688-1694.
 25. Kaplan GG, Panaccione R, Hubbard JN, et al. Inflammatory bowel disease patients who leave hospital against medical advice: predictors and temporal trends. *Inflamm Bowel Dis*. 2009;15(6):845-851.
 26. Talwalkar JA, Lindor KD. Primary sclerosing cholangitis. *Inflamm Bowel Dis*. 2005;11(1):62-72.
 27. Hughes JS, Iezzoni LI, Daley J, Greenberg L. How severity measures rate hospitalized patients. *J Gen Intern Med*. 1996;11(5):303-311.
 28. Jencks SF, Williams DK, Kay TL. Assessing hospital-associated deaths from discharge data: the role of length of stay and comorbidities. *JAMA*. 1988;260(15):2240-2246.
 29. Myers RP, Quan H, Hubbard JN, Shaheen AAM, Kaplan GG. Predicting in-hospital mortality in patients with cirrhosis: results differ across risk adjustment methods. *Hepatology*. 2009;49(2):568-577.
 30. Cima RR, Pemberton JH. Surgical management of inflammatory bowel disease. *Curr Treat Options Gastroenterol*. 2001;4(3):215-225.
 31. Shammash JB, Ghali WA. Preoperative assessment and perioperative management of the patient with nonischemic heart disease. *Med Clin North Am*. 2003;87(1):137-152.
 32. Fonager K, Sorensen HT, Rasmussen SN, Moller-Petersen J, Vyberg M. Assessment of the diagnoses of Crohn's disease and ulcerative colitis in a Danish hospital information system. *Scand J Gastroenterol*. 1996;31(2):154-159.
 33. Quan H, Parsons GA, Ghali WA. Assessing accuracy of diagnosis-type indicators for flagging complications in administrative data. *J Clin Epidemiol*. 2004;57(4):366-372.
 34. Ghali WA, Quan H, Brant R. Risk adjustment using administrative data: impact of a diagnosis-type indicator. *J Gen Intern Med*. 2001;16(8):519-524.
 35. Agency for Healthcare Research and Quality. Healthcare Cost and Utilization Project (HCUP) database. May 2011. Agency for Healthcare Research and Quality Web site. <http://www.hcup-us.ahrq.gov/nisoverview.jsp>. Accessed May 31, 2011.

INVITED CRITIQUE

Is Risk Calculation Risky?

In this issue of the *Archives of Surgery*, Kaplan et al¹ use the Nationwide Inpatient Sample, a large administrative database, to analyze the association of various coded conditions on inpatient mortality rate, length of stay, and hospital charges after operations on patients with Crohn disease or ulcerative colitis. The authors have found that an increasing number of comorbid conditions lead to worse outcomes. For example, as diagrammed in the Figure, performing an elective operation on a young patient with no comorbidities might

convey an average in-hospital mortality of 0.1%, but an emergency admission and subsequent operation on an elderly patient with at least 2 comorbidities might assume a 20.6% mortality risk.

Large database studies are appealing; Healthcare Cost and Utilization Project Nationwide Inpatient Sample data, in particular, supply a stratified 20.0% sample of US hospital admissions and provide sufficient power to analyze research questions involving infrequent outcomes, such as inpatient mortality. However, the breadth of large