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The Association of Inflammatory Bowel Disease and Immediate Postoperative Outcomes Following Lumbar Fusion

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Abstract

Background context—The United States Centers for Disease Control estimates the prevalence of inflammatory bowel disease (IBD) at over 3.1 million people. As diagnostic techniques and treatment options for IBD improve, the prevalence of IBD is expected to increase. For spine surgeons, patients with IBD have a unique complication profile because IBD patients may present with poor nutritional status and because the medications used to manage IBD have been associated with poor vertebral bone mineralization and immunosuppression. Presently, there are very limited data regarding perioperative outcomes among patients with IBD who undergo spinal surgery. The present study begins to address this knowledge gap by describing trends in lumbar fusion patients with IBD and by quantifying the association between IBD and immediate postoperative outcomes using a large, national database.

Purpose—To advance our understanding of the potential pitfalls and risks associated with lumbar fusion surgery in patients with inflammatory bowel disease.

Study Design/Setting—Retrospective cross-sectional analysis

Patient sample—The Nationwide Inpatient Sample database was queried from 1998 to 2011 to identify adult patients (18+) who underwent primary lumbar fusion operations using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) coding.

Outcome Measures—Incidence of lumbar fusion procedures, prevalence of IBD, complication rates, length of stay, and total hospital charges.

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Methods—The annual number of primary lumbar fusion operations performed between 1998 and 2011 was obtained from the Nationwide Inpatient Sample (NIS) database. Patients younger than 18 years of age were excluded. The prevalence of IBD in this population (both Crohn's disease and ulcerative colitis) was determined using ICD-9-CM codes. Logistic regression models were estimated to determine the association between IBD and the odds of postoperative medical and surgical complications, while controlling for patient demographics, comorbidity burden, and hospital characteristics. The complex survey design of the NIS was taken into account by clustering on hospitals and assuming an exchangeable working correlation using the discharge weights supplied by the NIS. We accounted for multiple comparisons using the Bonferroni correction and an alpha level for statistical significance of 0.0028.

Results—The prevalence of IBD is increasing among lumbar fusion patients, from 0.21% of all lumbar fusion patients in 1998 to 0.48% of all lumbar fusion patients in 2011 ($p<0.001$). The odds of experiencing a post-operative medical or surgical complication were not significantly different when comparing IBD patients to control patients without IBD after controlling for patient demographics, comorbidity burden, and hospital characteristics (adjusted odds ratio=1.1, 95% confidence interval [CI] 0.99–1.3, $p=0.08$). On multivariable analysis, the presence of IBD in patients undergoing lumbar fusion surgery was associated with longer length of stay and greater hospitalization charges.

Conclusions—Among lumbar fusion patients, IBD is a rare comorbidity that is becoming increasingly more common. Importantly, IBD patients were not at increased risk of postoperative complications. Spine surgeons should be prepared to treat more IBD patients and should incorporate the present findings into preoperative risk counseling and patient selection.

Keywords

inflammatory bowel disease; lumbar fusion; immediate postoperative outcomes

Introduction

The United States Centers for Disease Control (CDC) estimates the prevalence of inflammatory bowel disease (IBD) at 3.1 million adults, or 1.3% of the adult population.^[1] As both diagnostic techniques and treatment options for IBD (including both Crohn's disease and ulcerative colitis) improve,^[2] the prevalence of IBD is expected to increase in the coming decades.^[1] Specifically, the CDC estimates a higher IBD prevalence among adults aged 45 years and older,^[1] an age strata that is also at increased risk for degenerative diseases of the subaxial spine. As the U.S. population continues to age, the demand for spinal surgery among patients with IBD is, therefore, expected to grow.

Patients with IBD may present a unique complication profile to spine surgeons because IBD predisposes patients to poor nutritional status.^[3] Prior studies have consistently shown malnutrition to be a significant predictor of adverse perioperative outcomes following spinal surgery.^[4–7] Additionally, patients with Crohn's disease have been found to present with low lumbar spine bone mineral density.^[8] A common sequela of IBD,^[8,9] low bone mineral density, is also a known risk factor for suboptimal bone healing following spinal surgery.^[10] Furthermore, immunosuppressive agents such as systemic and topical corticosteroids are

used in the treatment of active disease, and the use of high-dose corticosteroids has been shown to contribute to reduced bone mineral density in patients with IBD.^[11–13] Additionally, management of IBD patients can be further complicated by the presence of chronic psychological stress and psychiatric disorders, such as depression and anxiety.^[14–19]

There exist very limited data describing perioperative outcomes among patients with IBD who undergo lumbar spine surgery, largely because IBD is a relatively rare comorbidity. National databases are, therefore, uniquely positioned to fill this gap in the literature. Improving our understanding of the association between IBD and postoperative outcomes following lumbar fusion can ultimately improve patient selection and preoperative risk counseling. The present study begins to address the dearth of data on this topic by quantifying trends in lumbar fusion patients with IBD and by determining the association between IBD and immediate postoperative outcomes using a large, nationally representative database.

Materials and Methods

Overview and Study Design

This study employs a retrospective cohort design and uses a nationally representative, all-payer database to quantify the prevalence of IBD among patients undergoing lumbar fusion and to determine the association between IBD and immediate postoperative outcomes in this population.

Data Source

This study used Nationwide Inpatient Sample (NIS) data from 1998–2011. Although there are some more recent NIS data available for purchase, this date range was chosen because the NIS underwent a sampling redesign in 2012 and because these data were available for analysis at our institution. The NIS is the largest all-payer healthcare database in the United States and annually collects data from over 1,000 U.S. hospitals.^[20] Specifically, the NIS is a nationally representative sample from across the United States and NIS data is comprised of a 20% stratified sample of all hospital discharges in the United States. Each patient discharge record corresponds to a single entry in the database and the NIS provides sampling weights that enable the generation of national estimates.

The NIS records patient-level data on demographics, comorbidities, diagnoses, procedures, outcomes (such as length of hospital stay, hospital charges, and mortality), in-hospital complications, and hospital characteristics (e.g., hospital size, geographic location, hospital teaching status).^[20] All diagnoses, procedures, and in-hospital complications are recorded in the NIS using International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes. Additionally, the NIS records Elixhauser comorbidity data from 1998 onward.^[21,22] The Elixhauser comorbidity index enables standardized risk adjustment using administrative data. Of the original thirty Elixhauser comorbidities, the NIS includes twenty-nine.^[21]

Study Population

Study hospital discharges were selected on the basis of the presence of an inpatient episode listing an ICD-9-CM procedure code for primary lumbar spinal fusion (81.04–81.08).^[23–26] All patients recorded in the NIS that underwent inpatient, primary lumbar fusion from 1998–2011 were initially included in the present study. The present study only included data from 1998 onward to mitigate the potential bias introduced by a change in 1998 to the sampling strategy AHRQ uses to create the NIS.^[27] Patients under 18 years of age were excluded from the present analysis. Over 33% of included patients were missing data on the approximate number of levels fused. We therefore did not include the number of levels in our analysis.

Outcome of Interest

Patients were identified as having IBD if their diagnoses included either ICD-9-CM codes for Crohn's disease (555.0, 555.1, 555.2, or 555.9) or ulcerative colitis (556.0–556.6, 556.8, 556.9).

Incidence of perioperative complications were calculated based on ICD-9 diagnosis codes that have been previously reported.^[28,29] Recorded complications included acute myocardial infarction (410, 410.01, 410.11, 410.2, 410.21, 410.3, 410.31, 410.4, 410.41, 410.5, 410.51, 410.6, 410.9, 410.91, 997.1), pulmonary embolism (415.11, 415.19), pneumonia (480 to 480.9, 481, 482 to 482.9, 483 483.1, 483.8, 484, 484.1, 484.3, 484.5 to 484.8, 485, 486, 487, 507), acute renal failure (584.5 to 584.9), deep vein thrombosis (453.4, 453.41, 453.42, 453.9), sepsis (995.91, 995.92), urinary tract infection (599, 997.5), acute respiratory failure (518.5–518.53, 518.81, 518.84, 997.3), complications related to the implant (996.2, 996.40, 996.42, 996.47, 996.49, 996.63, 996.66, 996.67, 996.75, 996.78, and 996.79), incidental durotomy (349.31 and 349.39), wound complications (998.83, 998.32, 998.51, 998.59, and 998.6), accidental puncture (998.2), hemorrhage or hematoma (998.11–998.13), acute kidney injury (584.5–584.9), and neurologic complications (997.00–997.09).

We also analyzed length of hospital stay (LOS) and hospital charges as outcomes of interest. Both LOS and total hospital charges were log-transformed prior to analysis and reverse transformed when interpreting our results. Hospital charges were adjusted for inflation using the Bureau of Labor Statistics CPI Inflation Calculator to 2011 U.S. dollars.^[30]

Analytic Approach

First, we used the discharge weights provided in the NIS to generate national estimates of the incidence of IBD among lumbar fusion patients for each year from 1998–2011. In our secondary analysis, we employed a generalized estimating equation multivariable logistic regression model using incidence of one or more complications as our outcome variable and IBD status, gender, age, Elixhauser comorbidities, elective versus emergent procedure, insurance status, hospital teaching status, hospital bed size, hospital region, and admission status as covariates.^[31] We also included each of these covariates in our model, based on *a priori* belief that the association between IBD and our outcomes of interest would be confounded by patient-and hospital-level characteristics. Notably, the list of included covariates is an exhaustive list of patient-and hospital-level characteristics included in the

NIS. We then estimated two additional linear regression models using log-transformed LOS and log-transformed hospital charges as the outcome variables. In all models, we adjusted for the clustering of observations on hospitals by assuming an exchangeable working correlation by labeling each hospital as a repeated factor. Due to the large sample size of the NIS and to adjust for multiple comparisons made in our regression models, we set our threshold for statistical significance at $p < 0.0028$ using a conservative Bonferroni correction.

The SAS statistical software package (version 9.4, SAS Institute Inc.) was used to calculate means, standard deviations, confidence intervals, and frequencies for patient demographics and hospital characteristics. Differences in normally distributed continuous variables at baseline between IBD and non-IBD patients were assessed using the independent t-test assuming unequal variance. Differences in non-normally distributed continuous variables were assessed using the Mann-Whitney-U test. Differences in categorical data at baseline were compared using the chi-squared test.

Results

A total of 514,572 adult lumbar fusion patients were identified in the NIS from 1998–2011. Among these patients, 1,791 (0.34%) patients had a diagnosis of IBD. The prevalence of IBD increased significantly over time from 0.21% of all lumbar fusion patients in 1998 to 0.48% of all lumbar fusion patients in 2011 ($p < 0.001$).

Patient Demographics and Hospital Characteristics

Table 1 presents the patient demographics and hospital characteristics of the study sample. Compared with controls, patients with IBD were significantly older (Median 57 years old vs. 55 years old, $p < 0.001$). Patients with IBD were more likely to be female (61% vs. 55%; p -value < 0.0001), more likely to be White (73% vs. 66%; p -value < 0.0001), and more likely to have insurance coverage through Medicare (37% vs. 32%; p -value < 0.0001). Patients with IBD were more likely to have deficiency anemia (12% vs. 8%; $p < 0.0001$), arthritis (8% vs. 3%; $p < 0.0001$), chronic lung disease (17% vs. 13%; $p < 0.0001$), depression (17% vs. 11%; $p < 0.0001$), hypertension (48% vs. 42%; $p < 0.0001$), hypothyroidism (11% vs. 9%; $p < 0.0001$), and electrolyte imbalance (13% vs. 8%; $p < 0.0001$). Finally, patients with IBD were less likely to have surgery at a hospital located in the Southern United States than patients without IBD (36% vs. 42%; $p < 0.0001$).

Post-operative Complications

The odds of experiencing an in-hospital complication were not significantly different when comparing patients with IBD to those without IBD after controlling for patient demographics, comorbidity burden, and hospital characteristics (adjusted odds ratio [aOR]=1.1, 95% confidence interval [CI] 0.99–1.3, $p = 0.08$). Table 2 shows the complete results of the model estimated with post-operative complication as the outcome of interest.

Length of Stay

Both groups (patients with IBD and patients without IBD) had a median post-operative LOS of 4 days (Interquartile Range 3–6 days vs. Interquartile Range 3–5 days, respectively;

p<0.001). In our multivariable analysis, patients with IBD had a 10% longer mean length of hospital stay than patients without IBD. (Table 2) The full results of this analysis are shown in Table 2.

Total Hospitalization Charges

The median value for hospitalization charges was \$28,023 for patients with IBD, and \$26,286 for patients without IBD (Interquartile Range \$20,269 – \$40,568 vs. \$18,907–\$37,068, respectively; p<0.001). (Table 1) In our multivariable analysis, the presence of IBD in patients undergoing lumbar fusion surgery was associated with 4.4% greater mean hospital charges (95% CI 1.6%-7.2%). The full results of this analysis are shown in Table 2.

Discussion

Using a nationally representative database, the present study addresses gaps in the literature on trends in lumbar fusion patients with IBD and the association between IBD and immediate post-operative outcomes. In the present study, the prevalence of IBD among lumbar fusion patients more than doubled from 1998 to 2011 (0.21% to 0.48% in 2011, p<0.001), which may in part be related to improved detection techniques for diagnosis.^[2] This result has two implications. First, spine surgeons should expect to see a greater percentage of their patients presenting with a concomitant IBD diagnosis. Second, when considered in the context of the growing incidence of lumbar fusion surgery,^[32–34] it is increasingly important for spine surgeons to understand the potentially unique complication profile of IBD patients as this chronic condition becomes increasingly prevalent.

Post-operative Complications

Lumbar fusion patients with IBD were not at increased risk of immediate post-operative complications, compared to patients without IBD. This finding differs from our hypothesis, because IBD patients are at increased risk of presenting not only with malnutrition,^[35–39] but also with significant chronic psychological comorbidities such as depression and anxiety,^[15,17,19] as well as immunosuppression from medications (e.g. high-dose corticosteroids).^[11–13] Prior studies have found that patients with poor nutritional status pre-operatively have increased rates of post-operative complications and readmission in surgeries of the spine, hip, knee, and shoulder.^[4,40–44] Specific to lumbar fusion surgery, three retrospective studies found that malnutrition increased the odds of post-operative infectious complications.^[5,40,45] In a single-institution study of 113 patients (n=29 malnourished) undergoing elective lumbar decompression and fusion, Klein et al. noted significantly more postoperative infectious complications in the malnourished group (as indicated by low serum albumin levels) compared to the nutritionally replete group.^[45] In a retrospective American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database review of 4,310 patients undergoing posterior lumbar spinal fusion, Bohl et al. found that patients with preoperative hypo-albuminemia (4.8% prevalence in the sample) had a higher relative risk of wound complications and surgical site infections than patients with normal albumin concentrations.^[40] In a PearlDiver Database retrospective cohort study of elderly patients with Medicare, Puvanesarajah et al. compared clinical outcomes of elective posterior lumbar fusion between 960 patients with malnutrition and 147,278 patients without malnutrition,

and found that malnutrition status was a significant predictor of increased odds of post-operative infection and wound dehiscence.^[5]

One possible explanation of our findings is that the complications described in other surgical populations largely became apparent following the index hospital stay. In contrast, our data only allowed us to study complications that developed during the index hospital episode, a time frame that may not adequately capture the potential effects of malnutrition, immunosuppression medication, or psychosocial factors on complication risk. In contrast, Klein et al. collected data on post-operative complications during an average follow-up period of three years.^[45] The ACS-NSQIP database utilized by Bohl et al. captured data on adverse events within 30 days of the surgical procedure,^[40] and the PearlDiver Patient Records Database utilized by Puvanesarajah et al. gathered data on infectious complications within one year of surgery.^[5] However, NIS data are only available for the inpatient episode and, therefore, we are unable to assess the incidence of wound infections and other post-operative complications that may develop after discharge.

Despite this inherent limitation of NIS data, the present study includes valuable data for spine surgeons. As IBD patients continue to comprise an increasingly larger share of lumbar fusion patients, it is important to understand the association between IBD and immediate post-operative outcomes. Our results suggest that further studies are warranted to determine whether patients with IBD are at increased risk of adverse outcomes immediately following discharge and up to several years following surgery. However, given the relatively low prevalence of IBD among lumbar fusion patients, such a study would be difficult to conduct at one or even multiple centers. The present study is, therefore, the first step toward addressing this question and uses the best available data to understand the association between IBD and postoperative outcomes.

Furthermore, our study is the first to directly compare patients with IBD to patients without IBD, and no prior studies reported the IBD prevalence among their study populations. Rather, the studies by Klein et al., Bohl et al., and Puvanesarajah et al. compared patients with pre-operative malnutrition status to well-nourished control patients.^[5,40,45] It is important to note the differences in defining poor nutritional status among these three studies. The study by Puvanesarajah et al. selected the malnutrition cohort by using ICD-9 codes for specific malnutrition disorders (i.e. kwashiorkor, marasmus, and other protein-calorie malnutrition), which introduces a potential for coding errors.^[5] In contrast, the studies by Klein et al. and Bohl et al. used serum albumin level as a proxy for nutrition status.^[40,45] While low serum albumin level is a common and widely accepted marker for malnutrition in the literature, the different definitions used in these three studies highlight a limitation in the methodology by which clinicians and researchers identify malnutrition.

Our study design differs from others in that we did not stratify patients according to preoperative hypo-albuminemia levels and instead sought to quantify the relationship between IBD and post-operative outcomes. This distinction is important because a diagnosis of IBD may predispose to, but does not equate with, poor nutrition status. For example, the retrospective NIS study by Nguyen et al. reported a significantly higher prevalence of malnutrition in 52,142 patients with IBD relative to a representative sample of 23,548

patients without IBD (6.7% vs. 1.8% respectively; $p<0.0001$).^[3] Importantly, the vast majority of patients with IBD included in the study by Nguyen et al. did not present with malnutrition, as indicated by the low prevalence rate.^[3] Whereas hypo-albuminemia is a potentially modifiable preoperative risk factor, IBD is a chronic disease that is increasing in documented prevalence among lumbar spine fusion patients and it, therefore, is important for surgeons to be able to incorporate IBD status into the preoperative decision-making process.

While the literature lacks studies on clinical outcomes among IBD patients undergoing spinal surgery, prior studies have quantified the complication and mortality rates in patients with IBD undergoing non-spine orthopedic surgery. One study by Kapadia et al. examined clinical outcomes of total hip arthroplasty in 17 patients with IBD and a matching cohort of 51 patients without IBD, and found that patients with IBD had overall higher revision and complication rates ($p<0.001$).^[44] While this study is limited by a small sample size, the authors provide insight into the potential association of IBD on implant survivorship.^[44] Due to data limitations, the present study could not be used to assess long-term implant survival. This issue merits further consideration in a future study.

Length of Stay

In the era of bundled payments and value-based reimbursement, length of hospital stay is an increasingly important metric regarding post-operative outcomes. In our multivariable analysis, IBD patients had a 10% longer mean length of stay relative to patients without IBD ($p\text{-value}<0.0001$). Other factors associated with an increased mean length of stay included increasing age, insurance status (Medicare or Medicaid relative to private insurance), female gender, hospital size (medium or large), race (African American, Hispanic, or Asian all relative to white), increasing number of comorbidities, and specific comorbidities (alcohol abuse, congestive heart failure, coagulopathy, electrolyte imbalance, metastatic cancer, paralysis, and pulmonary circulatory disease).

Our finding of an increased mean LOS in patients with IBD is consistent with studies by Bohl et al. and Puvanesarajah et al., that identified malnutrition as being associated with an increased length of stay following spine surgery ($p<0.001$ for both studies).^[5,40] Studies conducted in settings non-specific to spinal surgery have also reported similar findings. In a prospective study of 818 adults in the acute care hospital setting, Lim et al. found that malnourished patients had longer mean LOS (6.9 days vs. 4.6 days, $p < 0.001$), were more likely to be readmitted within 15 days ($p=0.025$), and had higher mortality rates ($p<0.001$).^[46] Similarly, in a retrospective National Surgical Quality Improvement Program (NSQIP) database study by Garcia et al. that investigated the impact of malnutrition on total shoulder arthroplasty, the authors found that malnourished patients had an increased risk of a longer hospital stay ($p<0.001$).^[43] Our findings in conjunction with prior studies suggest that contributions to length of stay may be multifactorial, but highlight the importance of considering nutritional status in IBD patients in the context of spinal surgery. In addition to nutritional status in surgical patients, other factors can be optimized. These include the management of comorbid diseases and control of post-operative pain, both of which may contribute to increased length of stay if poorly managed.^[47] As incentives under bundled

payment programs continue to evolve, our findings suggest that risk adjustment models should incorporate the prevalence of IBD in the population when determining targets for LOS following lumbar fusion. In the absence of appropriate risk adjustment, hospital systems will face a disincentive to treat IBD patients.

Total Hospitalization Charges

Total hospitalization charges are a key component in assessing the financial impact of a surgical procedure. A study by Kappelman et al. estimated the direct costs of IBD in the U.S. and found that hospitalization, outpatient care, and pharmaceutical claims all contribute to the substantial economic burden of this disease.^[48] In our study, the presence of IBD was associated with a 4.4% increase in mean hospitalization charges ($p<0.0001$).

The observed association between IBD and increased mean hospitalization charges is consistent with findings that have been reported in the literature. In a retrospective NIS study by Navaneethan et al. that assessed the impact of IBD in patients undergoing a cholecystectomy, the authors reported that following surgery, patients with IBD had higher mean hospitalization charges than patients without IBD (\$39,651 vs. \$35,196, $p=0.006$).^[49] Similarly, studies by Lim et al. and Chima et al. reported that patients at risk of malnutrition in the hospital setting have significantly increased costs of care relative to well-nourished patients ($p=0.014$ and $p<0.02$, respectively).^[46,50] In a study by Xu et al., the authors reported that increased hospitalization costs for IBD patients are associated with treatment drug of choice (infliximab), length of stay in the hospital, type of medical insurance, subtype of IBD, and use of hospital resources (i.e. surgery and endoscopy).^[51] In our study, the observed association between hospital charges and IBD in lumbar fusion surgery is likely multifactorial in nature, but can potentially be attributed to greater utilization of medical resources for the treatment of IBD, longer length of hospital stay, management of IBD-related complications, or poor nutritional status.

Limitations

There are several limitations to consider when interpreting the present study. First, the NIS records procedures and diagnoses using ICD-9-CM codes. Therefore, these data are subject to misclassification.^[28] Specifically, clinician notes are used to assign ICD-9-CM codes. If data are omitted from the note, then those data are, henceforth, not included in the NIS. Furthermore, we included ICD-9 codes 81.04 and 81.05 in this study with an eye toward including as many lumbar fusion patients as possible. However, these two codes also include “dorsal fusion,” and therefore may have been applied to some patients that did not undergo lumbar fusion which would tend to over-estimate the number of lumbar fusion procedures. Next, the NIS did not include data on the medication history of our study population. For example, the approximate number of levels fused was missing for over 33% of our study sample. The number of levels fused is an important marker of pathology severity and is a potential predictor of the outcomes analyzed in this study. Importantly, the present study could not determine whether IBD patients were undergoing immunosuppressive treatment prior to surgery. The medical management of IBD has changed considerably over time and new pharmaceutical products may change the risk of adverse events following surgery. Additionally, although NIS data are available for purchase through 2014, the present study

period ended in 2011 because the NIS underwent a survey redesign in 2012 and because more recent data were not available at our institution. However, there is no reason to suspect that the trend toward more IBD patients undergoing lumbar fusion changed from the end of the study period to the present. Finally, the NIS only includes data that are obtained during the inpatient episode. Therefore, as discussed previously, conditions and complications that may only become apparent with extended follow-up remain outside the scope of investigation of studies that utilize NIS data. Despite the limitations inherent to large, administrative databases, such data sources provide unique opportunities to study ecological and population-based trends for relatively rare diagnoses. Although we found that the prevalence of IBD among lumbar fusion patients increased significantly during the study period, the overall prevalence remained below 0.5%. Therefore, national administrative databases are uniquely positioned to address our study question.

Conclusions

IBD is a rare comorbidity that is becoming increasingly common among lumbar fusion patients in the United States. Importantly, our study showed that IBD patients undergoing lumbar fusion surgery were not at increased risk of immediate postoperative complications, however IBD patients may have higher risk of a longer hospital stay and greater hospital resource use. IBD is a chronic disease with a risk of disease progression or recurrence, and future prospective studies on long-term outcomes (such as quality of life and long-term hardware survival) following lumbar fusion surgery among IBD patients are warranted. The results of the present study suggest that spine surgeons should expect to treat more IBD patients and can incorporate the present findings into preoperative risk counseling and patient selection.

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Table 1
Demographics, Hospital Characteristics, Outcomes, and Hospital Charges for Lumbar Fusion patients with Inflammatory Bowel Disease and Controls

All data are from the Nationwide Inpatient Sample (NIS) database and include patients greater than 18 years of age who underwent primary lumbar spinal fusion from 1998–2011. Data listed in the IBD and No IBD columns are expressed as a raw value with percent of total fusions in patients with and without IBD, respectively, in parentheses. A “*” denotes a value less than 0.1% of the respective population, and thus not specifically reported in the NIS database. IBD is Inflammatory Bowel Disease. DM is Diabetes Mellitus. LOS is Length of Stay, measured in days. IQR is Interquartile Range, expressed as (Q1–Q3). Significance is set at $p < 0.0028$.

	Study Group, IBD (N=1791)	Control Group No IBD (N=512,781)	p-value
Age (y), Median (IQR)	57 (47–66)	55 (44–67)	<.001
Female, n (%)	1087 (60.7%)	281746 (55%)	<.0001
Race, n (%)			
White	1301 (72.6%)	335812 (65.5%)	<.0001
Black	*	25711 (5%)	<.0001
Asian	*	3911 (0.8%)	<.0001
Hispanic	*	23736 (4.6%)	<.0001
Other	*	9036 (1.8%)	0.005
Insurance, n (%)			
Medicare	665 (37.1%)	165712 (32.3%)	<.0001
Medicaid	*	24822 (4.8%)	0.0564
Private	910 (50.8%)	244003 (47.6%)	0.0148
Other	147 (8.2%)	78244 (15.3%)	<.0001
Comorbidity, n (%)			
Alcohol abuse	*	6910 (1.4%)	0.7628
Deficiency Anemia	212 (11.9%)	41672 (8.2%)	<.0001
Arthritis	134 (7.5%)	13694 (2.7%)	<.0001
Blood Loss Anemia	*	5446 (1.1%)	0.0672
Congestive Heart Failure	*	9085 (1.8%)	0.0513
Chronic Lung Disease	296 (16.6%)	67422 (13.2%)	0.0004
Coagulopathy	*	8613 (1.7%)	0.0057
Depression	301 (16.9%)	54096 (10.6%)	<.0001
DM	212 (11.9%)	62645 (12.3%)	0.5422
DM with Chronic Complications	*	6472 (1.3%)	0.1237
Drug Abuse	*	5543 (1.1%)	0.067
Hypertension	853 (47.8%)	213260 (41.8%)	<.0001
Hypothyroidism	196 (11%)	44272 (8.7%)	0.0023
Liver Disease	*	4122 (0.8%)	0.0003
Lymphoma	*	1508 (0.3%)	0.8288

	Study Group, IBD (N=1791)	Control Group No IBD (N=512,781)	p-value
<i>Electrolyte Imbalance</i>	233 (13.1%)	39827 (7.8%)	<.0001
<i>Metastatic Cancer</i>	*	4202 (0.8%)	0.7476
<i>Neurological Disorder</i>	*	14624 (2.9%)	0.0013
<i>Obesity</i>	177 (9.9%)	47119 (9.2%)	0.3582
<i>Paralysis</i>	*	10195 (2%)	0.2462
<i>Peripheral Vascular Disease</i>	*	8873 (1.7%)	0.2275
<i>Psychosis</i>	*	9644 (1.9%)	0.0014
<i>Pulmonary Circulatory Disease</i>	*	2352 (0.5%)	0.4148
<i>Renal Failure</i>	*	7358 (1.4%)	0.0096
Elective Procedure, n (%)	1403 (78.3%)	403444 (78.7%)	0.7279
Academic Hospital, n (%)	973 (54.8%)	272447 (53.4%)	0.5417
Hospital Size, n (%)			
<i>Small</i>	243 (13.6%)	66185 (12.9%)	0.5545
<i>Medium</i>	380 (21.2%)	113775 (22.2%)	0.4682
<i>Large</i>	1153 (64.4%)	329896 (64.3%)	0.9979
Hospital Location, n (%)			
<i>Northeast</i>	313 (17.5%)	74281 (14.5%)	0.0175
<i>South</i>	644 (36%)	215579 (42%)	<.0001
<i>West</i>	336 (18.8%)	101071 (19.7%)	0.5646
<i>Midwest</i>	498 (27.8%)	121850 (23.8%)	0.0033
LOS (d), Median (IQR)	4 (3–6)	4 (3–5)	<.001
Total Hospital Charges (\$), Median (IQR)	28,023 (20,269–40,568)	26,286 (18,907–37,068)	<.001

Table 2
Multivariable Analysis of Predictors for Lumbar Fusion post-operative Complications, Total Hospital Charges, and Length of Stay among Patients with Inflammatory Bowel Disease

All data are from the Nationwide Inpatient Sample (NIS) database and include patients greater than 18 years of age who underwent primary lumbar spinal fusion from 1998–2011. Data listed in the Complications column are calculated from logistic regression and expressed as adjusted Odds Ratio (aOR) with the 95% Confidence Interval (CI) in parentheses. Data listed in the Total Hospital Charges and Length of Stay columns are calculated from log transformation and regression and expressed as a percentage change with the % 95% Confidence Interval in parentheses. IBD is Inflammatory Bowel Disease. DM is Diabetes Mellitus.

	Complications	Total Hospital Charges	LOS
Parameter	aOR (95% CI)	Estimate % (% 95% CI)	Estimate % (% 95% CI)
IBD	1.1 (0.99 – 1.3)	4.4% (1.6% – 7.2%)	10.1% (7.1% – 13.2%)
Age	1 (1.01 – 1)	–0.3% (–0.3% – –0.2%)	0.2% (0.2% – 0.21%)
Insurance			
<i>Medicare</i>	1.1 (1.07 – 1.1)	–2.6% (–3.7% – –1.6%)	3.3% (2.4% – 4.3%)
<i>Medicaid</i>	1.1 (1.05 – 1.1)	2.8% (0.6% – 5%)	11.5% (9% – 14%)
<i>Other</i>	1 (1 – 1.1)	–0.9% (–2.4% – 0.6%)	2.4% (1.1% – 3.7%)
Elective procedure	0.6 (0.58 – 0.6)	–17.2% (–20.3% – –14%)	–32.8% (–35.4% – –30%)
Female	0.8 (0.77 – 0.8)	–2.1% (–2.6% – –1.5%)	4% (3.5% – 4.5%)
Hospital Size			
<i>Medium</i>	1.1 (1.04 – 1.2)	3.7% (–3.1% – 10.9%)	8.1% (2.7% – 13.6%)
<i>Large</i>	1.2 (1.13 – 1.3)	–0.4% (–6.3% – 5.9%)	14.6% (9.2% – 20.2%)
Academic Hospital	1.2 (1.17 – 1.3)	5.8% (1.7% – 10.1%)	15.3% (11.9% – 18.9%)
Race			
<i>Black</i>	1.1 (1.02 – 1.1)	–0.3% (–2.2% – 1.7%)	9.3% (7.6% – 11%)
<i>Hispanic</i>	1 (0.92 – 1)	–1.8% (–4.7% – 1.1%)	5.1% (2.1% – 8.2%)
<i>Asian</i>	0.9 (0.83 – 1)	0.3% (–3.2% – 3.9%)	8.7% (5.7% – 11.8%)
<i>Native American</i>	1.2 (1.04 – 1.4)	2.2% (–6.8% – 12%)	7.6% (–1.5% – 17.5%)
<i>Other</i>	1 (0.94 – 1.1)	5.3% (0.5% – 10.4%)	4.2% (–0.2% – 8.9%)
Hospital Region			
<i>Midwest</i>	0.9 (0.82 – 1)	5.3% (–1.7% – 12.8%)	–8.2% (–12.1% – –4.1%)
<i>South</i>	0.9 (0.87 – 1)	5.3% (–1.2% – 12.3%)	–8.1% (–11.7% – –4.4%)
<i>West</i>	0.9 (0.82 – 1)	21.1% (13% – 29.9%)	–12.5% (–16.4% – –8.3%)
Number of Comorbidities	1.6 (1.59 – 1.7)	12% (11% – 13%)	18.1% (17.1% – 19.2%)
Comorbidities			
<i>Alcohol abuse</i>	0.8 (0.79 – 0.9)	4% (1.8% – 6.3%)	10.2% (7.7% – 12.7%)
<i>Deficiency Anemia</i>	0.8 (0.81 – 0.9)	2.4% (0.6% – 4.3%)	2.5% (1.1% – 4%)
<i>Arthritis</i>	0.6 (0.57 – 0.6)	–7% (–8.3% – –5.7%)	–10.7% (–11.8% – –9.5%)
<i>Blood Loss Anemia</i>	0.9 (0.83 – 1)	5.5% (1.5% – 9.7%)	5% (1.8% – 8.3%)

	Complications	Total Hospital Charges	LOS
Parameter	aOR (95% CI)	Estimate % (% 95% CI)	Estimate % (% 95% CI)
<i>Congestive Heart Failure</i>	1.2 (1.13 – 1.3)	3.1% (1.1% – 5.1%)	11% (9% – 13.2%)
<i>Chronic Lung Disease</i>	0.7 (0.71 – 0.8)	–9.3% (–10.3% – –8.3%)	–13.1% (–14% – –12.2%)
<i>Coagulopathy</i>	1.3 (1.18 – 1.4)	28.9% (24.4% – 33.7%)	19.1% (16.8% – 21.4%)
<i>Depression</i>	0.6 (0.6 – 0.7)	–8.5% (–9.7% – –7.3%)	–12.9% (–14.1% – –11.7%)
<i>DM</i>	0.6 (0.59 – 0.6)	–11% (–12.1% – –10%)	–13% (–13.9% – –12.1%)
<i>DM with Chronic Complications</i>	0.8 (0.73 – 0.8)	–6.8% (–8.6% – –4.9%)	–0.4% (–2.3% – 1.6%)
<i>Drug Abuse</i>	0.7 (0.67 – 0.8)	2.3% (–0.2% – 4.9%)	8.9% (6.4% – 11.5%)
<i>Hypertension</i>	0.6 (0.54 – 0.6)	–11.6% (–12.6% – –10.7%)	–16.8% (–17.7% – –15.9%)
<i>Hypothyroidism</i>	0.6 (0.57 – 0.6)	–10.2% (–11.2% – –9.2%)	–14.8% (–15.7% – –13.9%)
<i>Liver Disease</i>	0.6 (0.59 – 0.7)	–7% (–9% – –4.9%)	–7.4% (–9.6% – –5.3%)
<i>Lymphoma</i>	0.6 (0.56 – 0.7)	5.6% (2% – 9.4%)	8.4% (4.6% – 12.3%)
<i>Electrolyte Imbalance</i>	1.7 (1.65 – 1.8)	19.1% (17.1% – 21.2%)	26.7% (24.7% – 28.7%)
<i>Metastatic Cancer</i>	0.7 (0.67 – 0.8)	30.5% (25.8% – 35.3%)	46.3% (41.5% – 51.2%)
<i>Neurological Disorder</i>	0.7 (0.67 – 0.7)	–5.3% (–6.5% – –4%)	–4.9% (–6.2% – –3.6%)
<i>Obesity</i>	0.7 (0.68 – 0.7)	–8.5% (–9.8% – –7.2%)	–12.2% (–13.3% – –11.1%)
<i>Paralysis</i>	0.9 (0.87 – 1)	9.6% (6.8% – 12.5%)	23.2% (19.4% – 27.1%)
<i>Peripheral Vascular Disease</i>	0.6 (0.59 – 0.7)	–10.7% (–12.4% – –9%)	–12.3% (–13.7% – –10.9%)
<i>Psychosis</i>	0.7 (0.7 – 0.8)	–4.3% (–6.2% – –2.3%)	–3.1% (–4.7% – –1.4%)
<i>Pulmonary Circulatory Disease</i>	2.7 (2.39 – 3.1)	15.3% (11.3% – 19.4%)	23.8% (19.6% – 28.1%)
<i>Renal Failure</i>	1.1 (1.02 – 1.2)	–6.1% (–7.9% – –4.2%)	–1.6% (–3.5% – 0.3%)
Year	1.03 (1.02 – 1.035)	3.5% (3% – 4%)	–2.8% (–3.1% – –2.6%)