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ORIGINAL ARTICLE

National Trends and Outcomes for the Surgical Therapy of Ileocolonic Crohn's Disease: A Population-Based Analysis of Laparoscopic vs. Open Approaches

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Abstract
Purpose The laparoscopic approach to Crohn's disease has demonstrated benefits in several small series. We sought to examine its use and outcomes on a national level.
Methods All admissions with a diagnosis of Crohn's disease requiring bowel resection were selected from the 2000–2004 Nationwide Inpatient Sample. Regression analyses were used to compare outcome measures and identify independent predictors of undergoing laparoscopy.
Results Of 396,911 patients admitted for Crohn's disease, 49,609 (12%) required surgical treatment. They were predominately Caucasian (64%), female (54%), and with ileocolic disease (72%). Most had private insurance (71%) and had surgery in urban hospitals (91%). Laparoscopic resection was performed in 2,826 cases (6%) and was associated with lower complications (8% vs. 16%), shorter length of stay (6 vs. 9 days), lower charges ($27,575 vs. $38,713), and mortality (0.2% vs. 0.9%, all $P<0.01$). Open surgery was used more often for fistulas (8% vs. 1%) and when ostomies were required (12% vs. 7%). Independent predictors of laparoscopic resection were age <35 [odds ratio (OR)=2.4], female gender (OR=1.4), admission to a teaching hospital (OR=1.2), ileocecal location (OR=1.5), and lower disease stage (OR=1.1, all $P<0.05$). Ethnic category, insurance status, and type of admission (elective vs. non-elective) were not associated with operative method ($P>0.05$).
Conclusions A variety of patient- and system-related factors influence the utilization of laparoscopy in Crohn's disease. Laparoscopic resection is associated with excellent short-term outcomes compared to open surgery.

Keywords Crohn's disease · Laparoscopic resection · Laparoscopic versus open resection

Introduction

Crohn's disease (CD) is a chronic, often debilitating, inflammatory disease without a definitive cure.[1] As Crohn's disease frequently presents during early adulthood and is associated with a lifetime risk of recurrence, the preferred treatment of CD is medical therapy with aminosalicylates, immunomodulators, and steroids.[2] When medical management fails or complications of the disease arise, surgical therapy is often required. Unfortunately, despite advancements in the medical management, Crohn's patients have a 70–90% lifetime likelihood of undergoing surgical intervention.[3,4]

Since the introduction of laparoscopic colon resection in 1991.[5] and subsequent trials leading to its acceptance for resection of malignancy,[6] its use for other intestinal pathology has increased.[7,8] Over the last decade, there have been several studies documenting the safety and feasibility of the laparoscopic approach for refractory CD.[9,10] Improvements in postoperative pain with decreased narcotic use, shorter length of hospital stay, more rapid return of bowel function, faster ability to tolerate oral intake after

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surgery, and lower overall postoperative morbidity have been shown to be significantly less with a laparoscopic approach than following open resection.[5,7–9,11–22] While over 10 years of existing literature reflects benefits for laparoscopic bowel resection in CD when compared with the traditional open approach, there has been hesitancy to adopt this technique in widespread use. Deterrents include patient factors well known to CD, such as severe mesenteric thickening, widespread inflammation, and a multifocal pattern, all making the operative technical management challenging to even the most experienced surgeons in conventional settings.[7,12,14] Other factors such as the urgency of the operation and the often difficult clinical condition for which the intervention is based upon (i.e., complex phlegmons, fistulas, or high-grade obstruction) may be hindrances to the laparoscopic approach. Longer operative times for a laparoscopic resection may, for some surgeons, outweigh the benefits of a quicker recovery. Finally, concerns regarding the ability to adequately evaluate of surgical margins to provide a safe excision of inflamed tissue by this method have pushed some surgeons away from minimally invasive techniques with this disease process.

Despite these concerns, laparoscopy has been shown to be effective and safe in this patient population when both performed by surgeons possessing the necessary skills and choosing the proper patients. Although large-scale data are still lacking, the available information suggests minor benefits to laparoscopy. Highlighting this, a recent Cochrane review identified only two randomized controlled trials comparing the open and laparoscopic approaches.[5,14] The remaining studies consist of case series, mostly from single institutions, representing less than 100 patients each and often consist of specialized institutions where experience and expertise may not accurately reflect generalizable results. Thus, the objective of our study was to analyze national trends in the surgical management of ileocolic CD from a large, population-based sample by comparing demographic and outcome measures associated with undergoing a laparoscopic versus open resection, as well as the variables affecting patient selection for each approach.

Materials and Methods

Data for this study were collected from the 2000 through 2004 Nationwide Inpatient Sample (NIS), an administrative database provided by the Department of Health and Human Services and a product of the Health Care Utilization Project, Association for Healthcare Research and Quality. The NIS is the largest inpatient, all-payer database in the USA. It contains information on patient demographics and comorbidities, admission and discharge diagnoses, and multiple outcome measures for approximately eight million hospital admissions each year. This database uses a stratified sampling frame and discharge weights to create accurate national estimates from an approximate 20% sample of all nationwide discharges. This includes all hospital types (private, not-for-profit, government, state) and regions of the country (Northeast, Midwest, South, and West). During our study period, between 986 and 1,004 hospitals from 33–37 states were sampled by the NIS. States excluded from each year group were not identical from year to year. The NIS also contains multiple validated severity adjustment measures to estimate patient disease severity used for clinical comparisons.

Patients included in the study were identified within the NIS dataset for the period of 2000 through 2004 using *International Classification of Disease, Ninth Revision, Clinical Modification* (ICD-9-CM) codes. Initial inclusion criteria involved patients with a primary admission diagnosis of Crohn's disease (555.0, 555.1, 555.9). Those who did not undergo bowel resection during their admission and those with isolated anal surgeries were excluded from the cohort. In addition, those who were deemed less likely to be offered the laparoscopic approach due to disease location or extent, including patients who required a transverse colectomy (45.74), total abdominal colectomy (45.8), and all rectal cases (48) were excluded from our analysis. Patients were then classified by type of surgical procedure they received by ICD-9-CM procedure codes, including ileocectomy (45.72), small bowel resection (45.60–45.62), right hemicolectomy (45.73), left hemicolectomy (45.75), and sigmoidectomy (45.76).

Definition of Variables

The primary variable in this study was the method of repair, defined by the laparoscopic designation (ICD-9-*CM* code 54.21) versus open approach. All patients with the ICD-9-CM code documenting a laparoscopic procedure, which also accounted for those who were converted to an open procedure, were included in the laparoscopic arm of our study for intention-to-treat purposes of our analysis. This definition encompasses all variations on laparoscopic resection including laparoscopic-assisted and hand-assisted laparoscopic techniques.

Other variables included age (years), sex, race, geographic region (Northeast, Midwest, West, South), teaching status of the hospital (teaching, non-teaching), location of the hospital (urban, rural), calendar year (2000–2004), comorbidity, admission type (elective, non-elective), and insurance status (Medicare, Medicaid, private insurance, other). Disease location (ileocolic, small intestine, colon),

need for repair of a fistula or placement of an ostomy were also examined and compared between the two groups. For the purposes of comparison, we defined the remaining variables as follows.

Admission Type

Patients who were admitted under both elective and urgent or emergent settings were included in the dataset.

Race

The NIS database categorizes ethnicity as Caucasian, African-American, Hispanic, Asian, Native American, and other. Participants with Asian, Native American, and other categories (NIS variables race 4, 5, 6; $n=869$) were initially grouped together. In addition, ethnicity was also dichotomized to Caucasian and non-Caucasian for comparison in a separate analysis. Patients with missing data in the category of race were excluded from this portion of our analysis only.

Comorbidities

Comorbidity measures were identified using the Agency for Healthcare Research and Quality comorbidity software. This includes ICD-9-CM diagnoses and the diagnosis-related group in effect on the discharge date and is found within the NIS database.

Disease Severity

Patient disease severity was accounted for using two validated variables contained within the NIS provided by the Medstat Disease Staging™ software, version 5.21, *disease staging: principle stage* (DS Stage) and *disease staging: mortality scale* (DS Mtr S). Both variables use several patient specific parameters present at time of admission to provide a measure of severity for clinical comparison. Disease staging: principle stage is an assigned numerical value reflective of the level of severity of the patient's principle admitting diagnosis only. In our cohort, this would reflect the severity of Crohn's-related pathology for each admission. Disease staging: mortality scale is a calculated value used to predict in-hospital mortality and is based in part on a patient's preexisting comorbidities, as well as established mortality rates of the hospital of admission. Both variables became available within the NIS in the year 2002; therefore, admissions occurring earlier in our study time period are not included in our analysis ($n=19{,}405$). Severity scales such as the Crohn's disease activity index (CDAI) are not available in the NIS database.

Age

Age was analyzed as a continuous variable in univariate and multivariate analysis and was then subdivided into discrete age ranges (under 18, 19–35, 36–55, and 56–65 years and over 65 years) for the final multivariate model.

Insurance Status

Patients were evaluated by both primary and secondary payers (NIS variables PAY1 and PAY2, respectively). Participants were grouped into Medicare, Medicaid, and private insurance. All patients with secondary payer status private insurance were grouped and analyzed with the private insurance group. Patients with self pay, no charge, or other (NIS PAY1/PAY2=4, 5, and 6; $n=1786$) were grouped together as "Other".

Main Outcome Measures

Hospital Charges

Total hospital charges were calculated using the NIS variable TOTCHG (total charges cleaned). In general, these are charges, not costs, and do not include professional fees and non-covered charges, but do include emergency department charges prior to admission to the hospital.

Length of Hospital Stay

The length of the hospital stay was measured in days from the time of admission to the time of discharge.

In-Hospital Complications

In-hospital complications were based on ICD-9-CM codes and grouped into eight different categories as previously described by Guller et al.[23]: mechanical wound complications, infections, pulmonary, gastrointestinal tract, cardiovascular, and complications during the surgical procedure. The categories of mechanical wound and infectious complications were combined for the purpose of our analysis.

Hospital Discharge

The NIS database provides the following information about the patient's discharge status: routine discharge, short-term hospital stay, skilled nursing facility, intermediate care facility, discharge to another type of facility, home health care, left against medical advice, and died during hospitalization. Patients who died during the hospitalization ($n=446$) were excluded when evaluating this specific endpoint

only. Patients who left against medical advice were reclassified as routine discharge to home (NIS variables DISPUniform 1 and 7). Patients requiring home health care were similarly categorized and were evaluated separately (NIS variable DISPUniform 6). Patients requiring disposition to another facility were also categorized together and evaluated separately (NIS variables DISPUniform 2, 3, 4, and 5).

In-Hospital Mortality

Because the NIS database contains information regarding in-hospital stay only, deaths following discharge from the hospital are not included in this series.

Statistical Analysis

All data analysis was performed using SPSS 12.0 for Windows (SPSS Inc., Chicago, IL, USA). Because the NIS database is a 20% sample of the United States yearly inpatient admissions, weighted samples (NIS variable DISCWT) were used to produce national estimates for all analyses. Patients with invalid or missing data for the primary variables of interest were analyzed for any significant variance from the study population and then excluded for evaluation of that data element only. Appropriate statistical tests were used for both categorical variables (chi-square analysis or Fischer exact test) and continuous variables (Mann–Whitney *U* test or Student's *t* test) in the univariate analysis comparing laparoscopic versus open resection in surgical Crohn's disease. Variables which reached statistical significance in the univariate model were then entered into a block multiple linear or logistic regression model to identify independent factors associated with utilization of a laparoscopic approach. A separate multivariate regression analysis was conducted to identify predictors of in-hospital complications. In our model, we grouped the in-hospital complications variables into a single dependant variable.[23] We analyzed whether several demographic, diagnostic, and procedural variables of interest (including utilization of a laparoscopic approach) were predictive of in-hospital complications. Patient comorbidity profiles were accounted for in this analysis. Key variables of interest such as race, payer status, and hospital location were forced into the regression model even if they were not found to be significant on univariate analysis. Results are presented as adjusted odds ratios (OR) with 95% confidence intervals (95% CI) where appropriate. Statistical significance for this study was set an alpha of 0.05. This study was performed in accordance with the NIS Data User Agreement and approval was obtained through our local Institutional Review Board.

Results

From the 2000–2004 NIS database, we identified 396,911 patients admitted with the diagnosis of CD, of which 49,609 (12%) required resection during their admission. Patient mean age was 41.6±17.0 years, with a female (54.0%) and Caucasian (86.4%) predominance (see Table 1 for patient demographics). Patients received operations for CD mostly in urban settings (90.7%), at teaching hospitals (57.0%), and had private insurance (74.6%). The overall complication rate was 15%, with a low mortality rate of 0.9% for the entire cohort.

A laparoscopic approach was performed in 2,826 (6%) patients versus 46,783 (94%) patients undergoing open resection. For patients who received the laparoscopic approach, univariate analysis revealed a shorter length of hospital stay (6

Table 1 Patient Demographics

Variable (n=49,609)	Number	Percentage
Type of resection		
Open	46,783	94
Laparoscopic	2,826	6
Mean age (years)	41.6	N/A
Sex		
Female	27,035	54.0
Male	22,997	46.0
Race		
Caucasian	31,146	86.4
African-American	2941	8.2
Hispanic	1,075	3.0
Other	869	2.4
Calendar year		
2000	9,225	18.4
2001	10,180	20.3
2002	9,063	18.1
2003	10,796	21.6
2004	10,812	21.6
Primary payer		
Medicare	7,089	14.2
Medicaid	3,792	7.6
Private	37,291	74.6
Other	1,786	3.6
Location of hospital		
Urban	45,419	90.7
Rural	4,651	9.3
Teaching status of hospital		
Teaching	28,527	57.0
Non-teaching	21,543	43.0
In-hospital mortality	446	0.9

N/A not applicable

vs. 9 days), lower hospital charges ($27,575 vs. $38, 713), lower in-hospital complication rate (8% vs. 16%), and lower mortality (0.2% vs. 0.9%; all $P<0.01$; see Table 2). Patients undergoing laparoscopy were also more often discharged to home rather than another type of care facility or receive home health (91% vs. 85%, $P<0.01$). Laparoscopic surgery for CD was associated with fewer in-hospital pulmonary (0.4% vs. 2.6%, $P<0.01$), gastrointestinal (5.3% vs. 10.6%, $P=0.04$), and cardiovascular (0.2% vs. 0.9%, $P=0.03$) complications. Intraoperative (1.5% vs. 2.3%, $P=0.46$) and wound or infectious (0.5% vs. 1.5%, $P=0.12$) complications were not significantly different between the two groups. Of all admissions in which resection was performed laparoscopically, 51.1 % were considered elective admissions, as opposed to urgent or emergent, as reflected by NIS coding. Of admissions in which an open resection was performed, 54.2% were considered elective. Within the elective category ($n=24,995$) only 5% were approached laparoscopically. Preexisting comorbidities (Table 2) were comparable between the two groups, with the exception of anemia (12.3% vs. 5.9%, $P<0.01$) and chronic pulmonary disease (7.2% vs. 5.0%, $P=0.05$), which were more common in those receiving open resection. Renal failure, despite its overall infrequency, was more common (1.1% vs.0.4%, $P=0.03$) in those undergoing laparoscopic resection. Finally, as expected, fistula repair (8% vs. 1%) and ostomy placement (12% vs. 7%) were more common with open repair (both $P<0.01$).

Multivariate logistic regression analysis was conducted to determine factors influencing performance of a laparoscopic procedure for surgical CD. (Table 3) Predictors of undergoing laparoscopic surgery for CD were age less than 35 years (OR 2.4, 95% CI 1.9–2.8), female gender (OR 1.4, 95% CI 1.3–1.5), ileocecal disease location (OR 1.5, 95% CI 1.0–2.2), and designation of a hospital as a teaching facility (OR 1.2, 95% CI 1.1–1.4). Patients with Medicare insurance (OR 0.7, 95% CI 0.5–1.0) and increasing disease stage (OR=0.4, 95% CI 0.4–0.5) were less likely to undergo a minimally invasive approach. Race and admission type showed no significant association with operative method ($P>0.05$; Table 3). A separate multivariate logistic regression was conducted to determine predictors of wound, infectious, gastrointestinal, pulmonary, and cardiovascular postoperative complications. Fistula repair (OR 5.2, 95% CI 1.7–16.1, $P=0.05$), ostomy placement (OR 2.3, 95% CI 1.9–2.7, $P<0.01$), and open surgery (OR 3.4, 95% CI 1.4–8.1, $P<0.01$) were independently associated with in-hospital complications (Table 4).

Discussion

Proper patient selection for the laparoscopic versus open approach with CD is multifactorial, involving both patient-

Table 2 Laparoscopic Versus Open Resection: Univariate Analysis

Variable (n=49,609)	Laparoscopic	Open	P
Number	2,826 (6%)	46,783 (94%)	
Number of resections per year			<0.01
2000	531 (5.8%)	8694 (94.2%)	
2001	320(3.1%)	9860 (96.9%)	
2002	562 (6.2%)	8501 (93.8%)	
2003	670 (6.2%)	10,126 (93.8%)	
2004	748 (6.9%)	10,064 (93.1%)	
Mean age (years)	38±16.5	42±17.0	<0.01
Age range			<0.01
<18	8.8%	5.8%	
19–35	41.7%	34.5%	
36–55	32.4%	38.4%	
56–65	10.4%	10.7%	
>65	6.7%	10.5%	
Sex**			<0.01
Female	1,717 (60.9%)	25,318 (53.6%)	
Male	1,104 (39.1%)	21,893 (46.4%)	
Race			0.338
Caucasian	1,849 (88.6%)	29,947 (88.2%)	
Non-Caucasian	239 (11.6%)	3,997 (11.8%)	
Comorbidities			
Hypertension	15.1%	12.9%	0.15
Anemia	5.9%	12.3%	<0.01
Pulmonary	5.0%	7.2%	0.05
Renal	1.1%	0.4%	0.03
Diabetes	2.5%	2.7%	0.78
Cancer (without mets)	1.8%	2.3%	0.56
Obesity	0.9%	1.5%	0.28
Nutritional depletion	5.9%	6.3%	0.79
Fluid and electrolyte disorders	12.6%	14.5%	0.24
Admission type			<0.01
Elective	1,273 (51.1%)	23,772 (54.2%)	
Non-elective	1,216 (48.8%)	20,088 (45.8%)	
Primary payer			<0.01
Medicare	240 (8.5%)	6,849 (14.5%)	
Medicaid	238 (8.4%)	3,554 (7.5%)	
Private	2,120 (75.2%)	33,338 (70.7%)	
Other	223 (7.9%)	3,396 (7.2%)	
Region of hospital			<0.01
Northeast	653 (23.1%)	12,232 (25.9%)	
Midwest	825 (29.1%)	12,968 (27.4%)	
South	813 (28.7%)	15,621 (33.1%)	
West	540 (19.1%)	6,424 (13.6%)	
Location of hospital			0.24
Urban	2,556 (90.3%)	42,863 (90.7%)	
Rural	274 (9.7%)	4,377 (9.3%)	
Teaching status of hospital			<0.01

Table 2 (continued)

Variable (n=49,609)	Laparoscopic	Open	P
Teaching	1,678 (59.3%)	26,849 (56.8%)	
Non-teaching	1,152 (40.7%)	20,391 (43.2%)	
Extent resection			
Ileocecum	433 (25.0%)	9,836 (20.1%)	<0.01
Small intestine	458 (26.5%)	15,890 (32.5%)	<0.01
Right colon	749 (43.3%)	18,721 (38.3%)	0.56
Left colon	28 (1.6%)	1,811 (3.7%)	<0.01
Sigmoid	63 (3.6%)	2621 (5.4%)	0.02
Number of diagnoses per record	4.2	5.2	<0.01
Number of procedures per record	3.0	3.4	<0.01
Fistula repair	35 (1%)	3,272 (8%)	<0.01
Ostomy placement	162 (6%)	5,336 (11%)	<0.01
Length of stay (days)	6	9	<0.01
Disposition			<0.01
Home	2,267 (91.0%)	36,342 (84.7%)	
Other facility	30 (1.2%)	1,383 (3.2%)	
Home health/Hospice	194 (7.8%)	4,770 (11.1%)	
Total charges	2,267 (91.0%)	36,342 (84.7%)	<0.01
In-hospital complication	30 (1.2%)	1,383 (3.2%)	<0.01
Wound/Infection	194 (7.8%)	4,770 (11.1%)	=0.12
Pulmonary	13 (0.3%)	1,231 (2.6%)	<0.01
Gastrointestinal	149 (5.3%)	4,940 (10.6%)	0.04
Cardiovascular	5 (0.2%)	422 (0.9%)	0.03
Intraoperative complications	42 (1.5%	1,209 (2.3%)	0.46
Disease stage*	1.7	1.5	<0.01
Mortality score*	2.6	2.4	<0.01
In-hospital mortality	5 (0.2%)	441 (0.9%)	<0.01

Table 3 Independent Predictors of Undergoing Laparoscopic Resection

Variable	Odds ratio	95% CI	P
0	2.4	1.9–2.8	<0.05
Gender			
Female	1.4	1.5–1.5	<0.05
Male	1.0		
Non-white	1.0	0.9–1.2	0.64
Admission type			
Elective	0.9	0.8–1.0	0.21
Non-elective	1.0		
Teaching status of hospital			
Teaching	1.2	1.1–1.4	<0.05
Non-teaching	1.0		
Insurance status			
Medicare	0.7		
Medicaid	1.2	0.5–1.0	0.03
Private	1.1	0.9–1.7	0.27
Other	1.0	0.8–1.5	0.41
Primary disease stage (DS Stage)	0.42	0.4–0.5	<0.01
Mortality score (DS Mrt S)	0.99	0.9–1.0	0.12
Hospital region			
Northeast	0.6	0.5–0.7	<0.01
Midwest	0.9	0.7–1.0	0.15
South	0.5	0.4–0.6	<0.01
West	1.0		
Disease location			
Ileocecum	1.5	1.0–2.2	0.03
Small intestine	0.5	0.3–0.7	<0.01
Right colon	0.5	0.3–0.7	<0.01
Left colon	0.4	0.2–0.9	0.03
Sigmoid	0.3	0.2–0.7	0.01

specific and surgeon-specific factors. Variables ranging from the patient's clinical condition on presentation, prior surgical history, and even steroid use may affect this decision. Surgeon comfort level with laparoscopy also clearly plays a role, as the clinical manifestations of CD can be highly variable and technically challenging. It is with this background that we attempted to identify factors that go into choosing an operative approach.

The results of our analysis of the NIS database reflect demographic and outcomes largely similar to the existing literature. The young, predominantly Caucasian population reflected in our data mirrors the established epidemiology of CD. Approximately 10,000 patients with CD require surgery each year, and these patients receive care in urban settings, somewhat more often in teaching hospitals—all likely a reflection of the surgical complexity associated with CD. Likewise, patient selection for a laparoscopic procedure is influenced in part on surgeon level of expertise and comfort, and this choice was made more frequently at teaching institutions. Preexisting comorbidities were fairly similar between patients offered a laparoscopic versus open surgery; the mortality score, a variable within the NIS which accounts for baseline comorbidities, while different

Table 4 Independent Predictors of In-Hospital Complications

Variable	Odds ratio	95% C.I.	P
Fistula repair	5.2	1.7–16.1	0.05
Open surgery	3.4	1.4–8.1	<0.01
Ostomy placement	2.3	1.9–2.7	<0.01
Admission type			
Elective	0.8	0.6–1.1	0.22
Non-elective	1.0		
Age>35	0.9	0.2–4.6	0.98
Race	1.4	0.9–2.4	0.17
Teaching hospital	1.2	0.9–1.7	0.18

between the two groups on univariate analysis, was not predictive in the multivariate model. Not surprisingly, as evidenced by the lower primary disease stage in the laparoscopic cohort, our data showed that those who underwent an open procedure on the whole had more advanced pathology related to CD.

Disparities among race, income, gender, and insurance status have been also shown to influence treatment options in other disease processes including CD.[24–29] Although our analysis examines differences in selection between two different types of surgical therapy rather than the need for surgical management, we did not find ethnicity to be a factor in this choice. One possible explanation for our findings, acknowledging that race is often viewed as reflective of socioeconomic status, is an assumption that after decision to operate has been made, cost between the two operative approaches would not significantly differ. Technology availability in the lower socioeconomic settings could also influence method selection, but was not identified in the present series.

We did find that factors including female gender, younger age, and ileocolic resection were more likely associated to undergo a minimally invasive approach. One possible reason for this tendency is the notion that females, especially at younger ages, may be increasingly interested in a cosmetically pleasing result than males. Based on our regression analysis, this finding was independent of the disease severity, thus not simply a factor of more elective or less severe disease manifestations. Another notable difference between patients receiving laparoscopic versus open resection, possibly reflective of income, was insurance status. Our univariate analysis revealed that a higher percentage of patients undergoing laparoscopy held private insurance and that more patients who underwent open resection depended on Medicare. Multivariate analysis confirmed those with Medicare insurance more likely to undergo an approach. Though difficult to identify the exact reasons from this type of study, this may reflect advanced technology being used more often in patients with private paying insurance or, again, the technology more readily available in more affluent areas.

Although outcomes were not our primary goal, as non-randomized data such as these can lead to certain biases, we were able to identify certain trends. In addition, we attempted to evaluate whether complication rates were simply a product of our baseline differences in the two cohorts by multivariate analysis that included patient demographics and comorbidities. Similar to data from existing clinical studies which revealed a lower rate for overall postoperative morbidity for laparoscopic resection (12.8% vs. 20.2%, $P=0.01$) but no difference in individual complications,[4,5,7,11,13,16,19,21] our data showed an overall complication rate of 8% for laparoscopic and 16% for open resection ($P<0.01$). Patients undergoing laparoscopic resection had fewer cardiovascular, pulmonary, and gastrointestinal complications, again consistent with those from smaller series.[4,7,13,14] Rates of infectious or wound complications and intraoperative complications were not significantly different between those undergoing laparoscopic versus open resection in our analysis. Similarity in rates of intraoperative complications between the two groups, while likely somewhat reflective of the selection bias inherent in our comparison, may disprove the fear that a minimally invasive approach to CD could compromise patient safety. Not surprisingly, we found that patients with fistulas and cases in which a stoma was required were more apt to undergo an open exploration. With additional experience, even these cases may be more often approached via a minimally invasive technique. Increasing experience and larger randomized studies may confirm our findings and determine whether the benefits of laparoscopy extend beyond the short-term benefits.

Several studies cite the laparoscopic "learning curve" as a barrier to this technique's acceptance as a standard of care in CD.[4,19] During our study period from 2000 to 2004, the number of Crohn's resections performed laparoscopically increased at a rate that was statistically significant, though not necessarily clinically relevant. As graduating surgical residents are becoming more familiar with advanced minimally invasive surgical skills, this number is likely to increase. Due to the time period for which the NIS was available at the time of our analysis, our study may not reflect the most recent developments in this learning curve. As future data are released and experience evolves, we may see further development of these trends, including more equivalent operative times for laparoscopic surgery for CD when compared to open resection.[7,11,14]

We acknowledge several limitations to the present study. The NIS database allows examination of nationwide trends and outcomes, providing insight into how groups represented in smaller, more controlled studies compare to the general population. However, as an administrative database which relies on coding for accuracy, the NIS itself is subject to several significant limitations. Coding discrepancies are more likely to affect diagnostic and procedural variables that are not paramount to a patient's file for billing purposes. Also, as a consequence of this time period, there is a relative paucity of laparoscopic resections in the current population, with only 6% undergoing a minimally invasive operation. As increasing experience with performing laparoscopic resections in general is gained and its use is broadened, it will be interesting to see how changes may develop in the current study. Other limitations to the present study include the mere nature of an observational, retrospective study and the inherent biases associated with it. Large databases such as the NIS, while providing a large volume of information, lack specifics that could add to the study, i.e., why exactly was the method chosen, postoper-

ative stay versus total length of hospital stay, and specific severity scales such as CDAI. In addition, NIS provides no information on competency of the operation, including margins, recurrence, conversion rate to open, immunosuppressants, number of prior surgeries, readmission rates, and any data beyond the in-hospital complication or mortality data. It also does leave open the possibility of coding errors that may not only affect the type of procedure and perioperative data but also outcomes. Yet, our goal was to identify as best as possible what was taking place on a national level, and we were able to accomplish that goal. Additionally, the large sample size provided by the NIS database increases the likelihood of an even distribution of coding errors between the laparoscopic and open groups. Our analysis included patients who were admitted under both elective and urgent or emergent settings. This designation, assigned by NIS, pertains to clinical circumstance on time of admission, rather than at the time of surgery, which may differ in CD. Although considered by some to be a relative contraindication to laparoscopic resection, conditions such as complete bowel obstruction, hemorrhage, or peritonitis were also included in our analysis. A large multicenter prospective study examining outcomes for laparoscopic surgery for CD, with attention to both patient- and surgeon-related factors which contribute to the choice of operation, would add strength to the body of literature documenting the benefits of this approach.

Conclusion

Proper patient selection when choosing an operative approach is even more important in disease process such as Crohn's. In this large nationwide database evaluation, we found that laparoscopy for Crohn's disease is associated with improved outcomes such as cost, length of hospital stay, discharge disposition, postoperative gastrointestinal, pulmonary and cardiovascular complications, and mortality compared to open resection. Although factors such as younger age, female gender, and ileocecal disease location were identified as predictors of undergoing laparoscopy, we found no influence of level of urgency of admission or race on the utilization of a laparoscopic approach. Future analysis of data as laparoscopic resections for Crohn's disease gain widespread use and acceptance will further clarify factors that influence the choice of and access to this surgical approach.

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