Identification of diverticulitis patients at high risk for recurrence and poor outcomes

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BACKGROUND: Currently, the indications for elective surgery for patients who have recovered from an acute diverticulitis (AD) are controversial. We examined the natural history of AD in New York and identified risk factors for recurrent admissions and poor outcome to create a simple model to produce risk stratification groups. Poor outcome was defined as complicated disease, emergency surgery, or mortality during any recurrent admission.

METHODS: Data on adult diverticulitis admissions between 1985 and 2006 were extracted from the state discharge database; recurrences were monitored using unique identifiers. Survivors of nonoperative management who did not undergo subsequent elective surgery were considered eligible for recurrence. Clinical variables from the first admission with significant association with poor outcomes or recurrence were identified using multivariable analysis and were used to create risk stratification groups.

RESULTS: A total of 237,879 individuals were identified. Of the 181,115 patients eligible for recurrence after one admission, 8.7% recurred; of the patients eligible for recurrence after two admissions, 23.2% recurred. Complicated AD or abscess and age less than 50 years allowed the creation of discrete risk groups for both recurrence and poor outcome.

CONCLUSION: The majority of patients (91.3%) had no further admissions for AD. However, patients admitted for recurrence were increasingly likely to require subsequent admissions. Patients with complicated AD at the first admission, specifically abscess, had a high risk of recurrence and poor outcome and should be offered surgery. Younger patients also had higher recurrence and poor outcomes. We provide a risk stratification model to help identify patients at high risk for recurrence and poor outcome.
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LEVEL OF EVIDENCE: Therapeutic study, level IV; epidemiologic/prognostic study, level III.

KEY WORDS: Acute diverticulitis; colectomy; colostomy; surgical outcomes.

Diverticular disease has a remarkably high prevalence in Western countries, leading to nearly 300,000 hospitalizations and 1.5 million outpatient visits per year in the United States.[1,2] While the majority of diverticulitis patients recover without incident, as many as 25% of patients require emergent operative treatment, leading to complications and fecal diversion in more than 50% of cases.[3,4]

Currently, controversy exists around the appropriateness of elective surgery for patients who have recovered from an acute diverticulitis episode. Although elective surgery leads to fewer complications and fewer colostomies than emergent surgery, it poses unnecessary risk in patients for whom recurrence risk is very low. Modern studies estimate that recurrence is lower than historically believed, ranging from 5% to 36%.[5–9] In 2000, the American Society of Colon and Rectal Surgeons published practice parameters suggesting that patients pursue elective surgery after two episodes of uncomplicated diverticulitis or one episode of complicated diverticulitis.[10] In 2006 and again in 2014, these parameters were updated based on newer data suggesting that recurrence rates were low and recurrent disease had low morbidity. These newer parameters suggest that the decision for surgery be made on a case-to-case basis but do not outline how to identify good candidates for surgery.[11,12] Many modern studies on diverticulitis are based on single-institution patient follow-up, underpowered to identify risk factors. Identification of individuals at high risk for recurrence or poor outcomes would allow clinicians to select patients for whom elective surgery would provide the most benefit.

We used the New York state discharge database to further characterize the natural history of diverticulitis. By using unique identifiers, we were able to track multiple admissions for recurrent diverticulitis during the study period. The purpose of this study was to describe the natural history of diverticulitis in a large population and create a risk stratification model to identify patients at high risk for recurrence and poor outcomes.

PATIENTS AND METHODS

A retrospective analysis was performed on data derived from discharge records collected by the New York Statewide Planning and Research Cooperative System (SPARCS) inpatient database, inclusive of 1985 to 2006. SPARCS is a robust, comprehensive data reporting system started in 1979 as a collaborative effort between the state and hospitals, which collects patient level detail on demographic information, patient characteristics, diagnoses and treatments, and services for every hospital discharge in New York State, in addition to other information. SPARCS uses the DRG International Classification of Diseases—9th Rev. (ICD-9) codes for patient medical information. This study was approved by the institutional review board at the Weill Cornell Medical College. Statistical analyses were performed using STATA/IC version 11.0 (College Station, TX).

Subject and Variable Extraction

All admissions with a diagnosis of diverticulitis (ICD-9 codes 562.11, 562.13) were included. Duplicate entries and admissions with concurrent diagnosis of colorectal cancer (ICD-9 codes 153.x, 154.x, 197.5, 230.x), inflammatory bowel disease (ICD-9 codes 555.x, 556.x), appendicitis (ICD-9 codes 540, 541, 542), and gastrointestinal hemorrhage (530.82, 531.0, 532.0, 533.x, 569.3,569.85, 578.x) were excluded. Unique patient identifiers allowed identification of multiple admissions.

Age at each presentation, sex, and comorbidities were extracted. Patient comorbidities were extracted from ICD-9 codes; these comorbidities were classified and assigned weighted scores to determine the Charlson comorbidity index, operationalized using the method described by Romano et al.[13] Patients were classified as having had surgery if their codes included a colectomy (ICD-9 codes 45.7x, 45.8), rectal resection (ICD-9 code 48.6x), or colostomy (ICD-9 codes 46.0, 46.03, 46.1x, 48.62). SPARCS classifies admission type as emergent, urgent, or elective; emergent and urgent admission types were combined as emergency admissions. Surgical procedures that occurred during elective admissions were designated as elective surgeries. All other surgeries were designated as emergency surgery.

Complicated diverticulitis was defined as patients with obstruction, (ICD-9 code 560), perforation (ICD-9 code 569.83), peritonitis (ICD-9 code 567.x), abscess (ICD-9 code 567.22 or 569.5), or required abscess drain placement without any other surgical procedures during that admission (ICD-9 code 549.1). Mortality was defined using the discharge destination field.

Demographic variables such as race and insurance were extracted for use as adjustors in the multivariable models. Hospital volume was calculated as the total number of admitted cases of diverticulitis seen during the 22-year period and was divided into quartiles for analysis. Patient home address zip codes were extracted; patients who did not reside in New York were excluded. Zip codes were matched to median household income using the US Census data, as a marker of socioeconomic status; admissions from 1985 to 1995 were matched to 1990 median income by zip code, adjusted to $2,000, while admissions from 1996 to 2006 were matched to $2,000 median income by zip code.

Outcomes of Interest

To determine the natural history of patients who were managed without surgery, subsequent admissions on patients who underwent surgery (elective or emergent) or died were censored. Patients who were managed nonoperatively and survived to discharge from one admission were considered eligible for elective surgery or recurrence. Outcomes of interest included recurrence and poor outcomes. Recurrence was defined as subsequent inpatient admissions with a diagnosis of diverticulitis for reasons other than elective surgery. "Poor outcome" was defined as complicated disease, emergency surgery with or without colostomy, or mortality in any recurrent admission.

Risk Stratification Modeling

Two-group comparisons to determine candidate variables for risk factor analysis used X^2 and Student's *t* tests. Candidate variables significant in the two-group comparisons were used to create a multivariable analysis to identify variables with the strongest associations with the outcomes of interest. Candidate variables included age at first captured admission, sex, and disease characteristics at the first admission; specific comorbidities were included if the incidence of the comorbidity was present in at least 3% of the patients eligible for recurrence. Continuous variables were further analyzed to identify cutoff points or interactions between variables. Significant variables from the two-group comparisons were assembled into multivariable logistic regression models, adjusted for year of admission, hospital volume quartile, race, insurance, and income. Variables significantly associated with either poor outcome and recurrence from the multivariable analysis were placed into a tree-shaped model to create risk stratification groups. Variables with the strongest association were tested as the first node of the model, and the remaining candidate variables were tested as secondary stratifiers. Logistic regression was performed to determine adjusted odds ratios (ORs) for each risk group. Emphasis was placed on using clinically plausible variables not likely to be affected by coding error in the database. We sought to create a model that would be easy for clinicians to use and remember, with statistically significant ORs differentiating low- and high-risk groups.

RESULTS

Descriptive Analysis

A total of 237,879 patients (female, 62.5%) were identified with at least one admission for diverticulitis (Table 1). Mean (SD) age at the first captured admission was 65 (15.7) years. Median Charlson comorbidity index score at first admission was 0 (range, 0–7); 86.1% of the patients had a score between 0 and 1.

During the first captured admission, 47,554 patients (20.0%) underwent surgery. Of the patients who underwent surgery, 19,565 (41.1%) received an ostomy. Of the patients, 6,887 (2.9%) expired. Death rate was higher for surgical patients (2,836 deaths, 6.0%) than for nonsurgical patients (4,051 deaths, 2.1%). A total of 5,159 patients had elective surgery after the first admission; of these patients, 369 received an ostomy (7.2%).

Recurrence and readmission patterns are shown in Figure 1. Of the 181,115 patients eligible to recur after one admission, 15,772 (8.7%) recurred. Of 11,787 patients eligible to recur after two admissions, 2,738 (23.2%) had more than one recurrence. Of all patients, 57,235 (24.1%) underwent emergency or elective surgery at some point. Of the 9,708 surgeries that did not occur at the first captured admission, 6,555 (67.5%) were elective and 3,153 (32.5%) were emergent. Colostomy creation was significantly higher in patients who had emergent surgery compared with elective surgery (39.3% vs. 6.7%, $p < 0.001$). Mortality was also significantly higher in patients who had emergent surgery (4.6% vs. 0.3%, $p < 0.001$).

TABLE 1. Patient Population at First Admission

Characteristic	n	%
All patients	237,879	
Female	148,671	62.5
Age	Mean, 65.2	SD, 15.7
	Median, 67	
≤40	17,669	7.4
41–50	30,451	12.8
51–60	40,108	16.9
61–70	49,085	20.6
71–80	57,164	24.0
81–90	36,792	15.5
>90	6,610	2.8
Emergency admission	194,454	81.9
Charlson comorbidity index score		
0	140,917	59.2
1	63,793	26.8
2	24,201	10.2
3	6,954	2.9
≥4	1,684	0.9
Most common comorbidities		
Pulmonary disease	31,314	13.2
Mild diabetes mellitus	25,525	10.7
Congestive heart failure	19,811	8.3
Malignancy	12,542	5.3
Myocardial infarction	8,670	3.6
Peripheral vascular disease	7,379	3.1

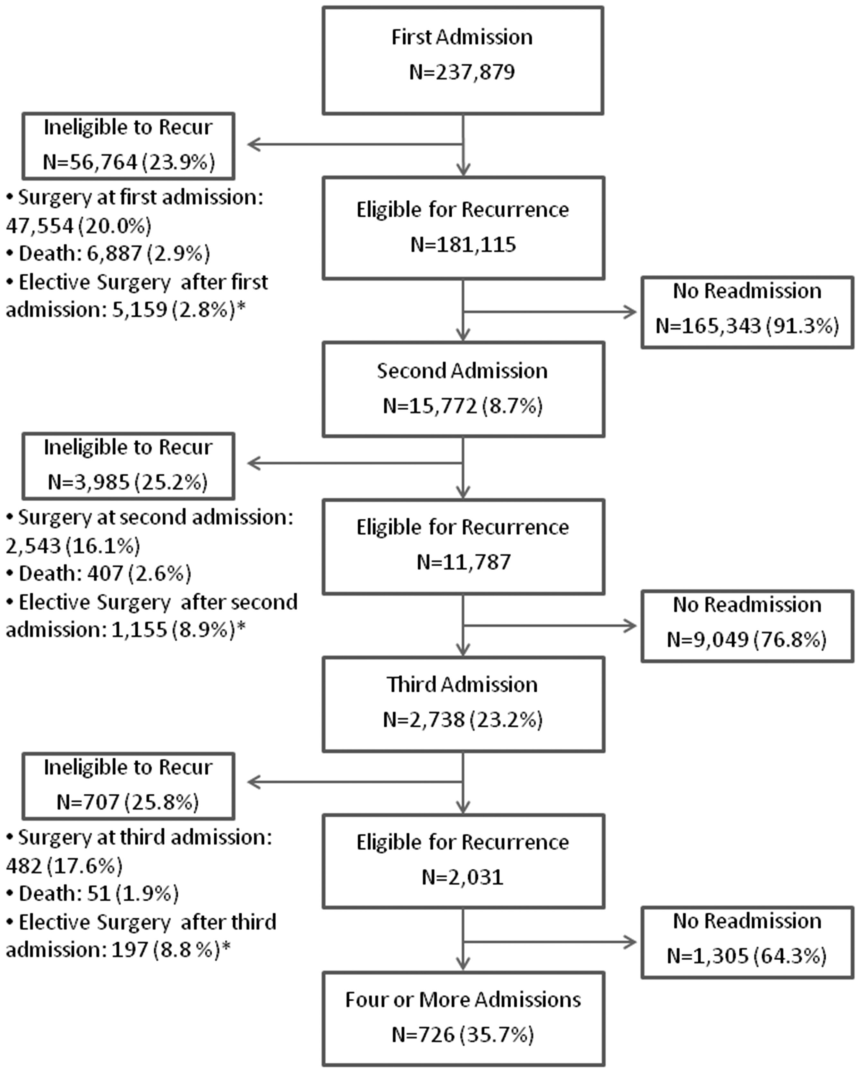

Figure 1. Patient recurrence and readmission. *Percentage for elective surgeries calculated from survivors without previous surgery discharged from previous admission.

Among patients eligible for recurrence after each subsequent episode, recurrence and poor outcomes increased as the number of admissions increased (Table 2).

Risk Stratification Modeling

Two-group comparisons (not shown) identified age, female sex, abscess, peritonitis, and pulmonary disease as being associated with increased risk of recurrence. Age, Charlson comorbidity index score, abscess, peritonitis, perforation, obstruction, myocardial infarction, and pulmonary disease were associated with poor outcomes. Age was further explored to determine a cutoff point for dichotomizing into low-risk and high-risk groups. Patients 50 years or younger at the first captured admission had a very slight increase in recurrences and poor outcomes as compared with patients older than 50 years ($p < 0.05$). For risk stratification analysis, age was dichotomized into two groups: those 50 years and younger and those older than 50 years. Logistic regression confirmed that this dichotomized variable was associated with recurrence and poor outcomes ($p < 0.001$ for both).

Adjusted multivariable logistic regression models are shown in Table 3. Abscess at the first admission was the strongest predictor of readmission and poor outcomes during readmissions. All variables contributing to the composite variable of complicated diverticulitis were associated with poor outcomes; abscess drain and peritonitis were also associated with recurrence. Therefore, we explored models using both complicated diverticulitis as well as abscess alone as the first stratifier variable. Age,

TABLE 2. Rate of Recurrence and Poor Outcomes in Patients Eligible for Recurrence

	Eligible to Recur	Recurrence	Poor Outcome
After one admission	181,115	15,772 (8.7%)	4,250 (2.4%)
After two admissions	11,787	2,738 (23.2%)	771 (6.5%)
After three admissions	2,031	726 (35.8%)	164 (8.1%)
After four admissions	608	250 (41.1%)	114 (8.6%)
After five admissions	215	98 (45.6%)	43 (20.0%)

TABLE 3. Multivariable Logistic Regression of Candidate Variables*

Variable	OR	95% CI	*Z* score	*p*
For Recurrence (Model *p* = 0.000)				
Age ≤ 50 y	1.20	1.15–1.26	7.52	0.000
Female	1.20	1.15–1.24	9.68	0.000
Abscess	1.67	1.45–1.94	6.93	0.000
Peritonitis	1.23	1.08–1.40	3.14	0.002
Perforation	1.21	0.92–1.58	1.35	0.177
Obstruction	1.08	0.99–1.17	1.83	0.068
Congestive heart failure	0.86	0.81–0.92	−4.44	0.000
Pulmonary disease	1.27	1.21–1.33	9.87	0.000
Malignancy	0.77	0.70–0.84	−5.58	0.000
For poor outcome (model *p* = 0.000)				
Variable	**OR**	**95% CI**	***Z* score**	***p***
Age ≤ 50 y	1.17	1.08–1.28	3.76	0.000
Female	1.05	0.98–1.12	1.34	0.180
Abscess	3.84	3.22–4.58	14.89	0.000
Peritonitis	1.84	1.54–2.19	6.71	0.000
Perforation	1.91	1.32–2.76	3.44	0.000
Obstruction	1.78	1.58–2.02	9.19	0.000
Congestive heart failure	0.84	0.74–0.95	−2.86	0.004
Pulmonary disease	1.24	1.14–1.36	4.98	0.000
Malignancy	0.76	0.64–0.90	−3.22	0.001

*Adjusted for year, hospital volume quartile, race, insurance, and income.

when placed as the second node in the tree, generated groups that were significantly discriminative for recurrence and poor outcomes (Fig. 2). The use of abscess in the model created smaller high-risk groups but better discrimination between risk groups.

ORs for each risk stratification group are shown in Figures 2 and 3. When using complicated diverticulitis and age as the stratifiers, the lowest-risk group had a recurrence rate of 8.4% and poor outcome rate of 2.1%. The highest-risk group, patients younger than 50 years with complicated diverticulitis at the first admission, had a recurrence rate of 13.7% (adjusted OR, 1.76; 95% confidence interval [CI], 1.51–2.04) and a 7.3% incidence of a poor outcome (adjusted OR, 3.27; 95% CI, 2.68–3.99). When abscess and age are used to stratify, the higher-risk groups are much smaller, but the stratification is more pronounced: the lowest risk group had a recurrence rate of 8.4% and poor outcome rate of 2.3%. The highest-risk group had a recurrence rate of 18.2% (adjusted OR, 2.46; 95% CI, 1.89–3.21]) and a 13.7% incidence of a poor outcome (adjusted OR, 6.09; 95% CI, 4.51–8.24). Adjusted ORs for specific risk groups are presented in Table 4.

DISCUSSION AND CONCLUSION

Our ability to select appropriate candidates for elective surgery after resolution of an acute diverticulitis episode is limited. Although modern studies show the risk of observation is lower than previously believed, expectant management is not without significant risk. Emergency surgery leads to high rates of colostomy and mortality.[14,15] One of the main goals of elective surgery is the avoidance of a colostomy, as reversal rates are low and complications are high, even in the modern era.[16] We believe that patients who have recovered from acute diverticulitis would consider elective surgery as a way to avoid any poor outcome, including emergency surgery, complicated diverticulitis, and death. To help clinicians and patients weigh the risks and benefits of surgery, we chose to classify all poor outcomes as a single group instead of weigh each outcome individually.

In a population-based analysis of Washington state, Anaya et al.[7] determined that only 5.5% of the patients who recovered from an initial diverticulitis event ever required

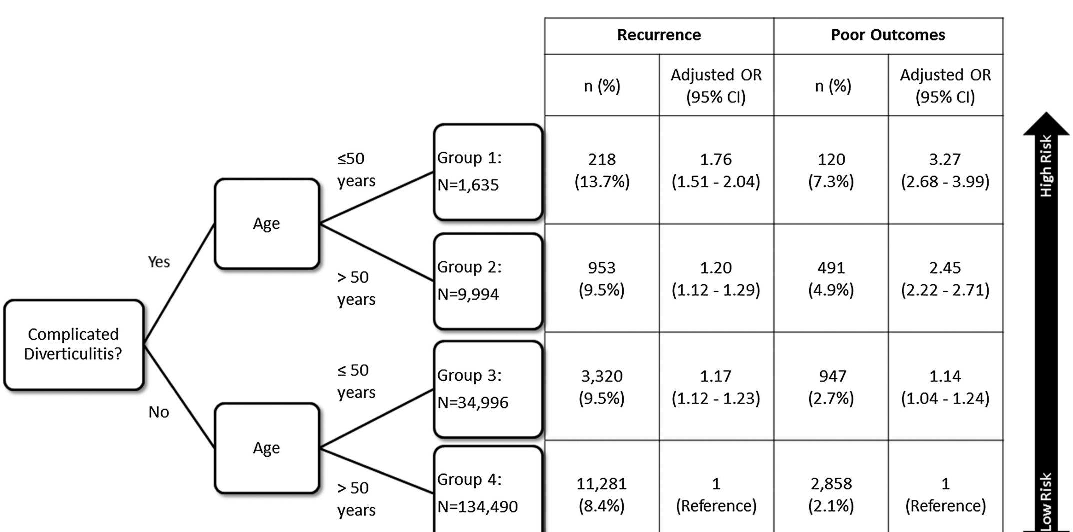

Figure 2. Model 1: risk stratification groups using complicated diverticulitis and age. Adjusted ORs represent logistic regression for patients who were eligible for recurrence, adjusted for year, patient factors (age, sex, comorbidities, median income by zip code, insurance type, and race) and hospital factors (hospital volume by quartile).

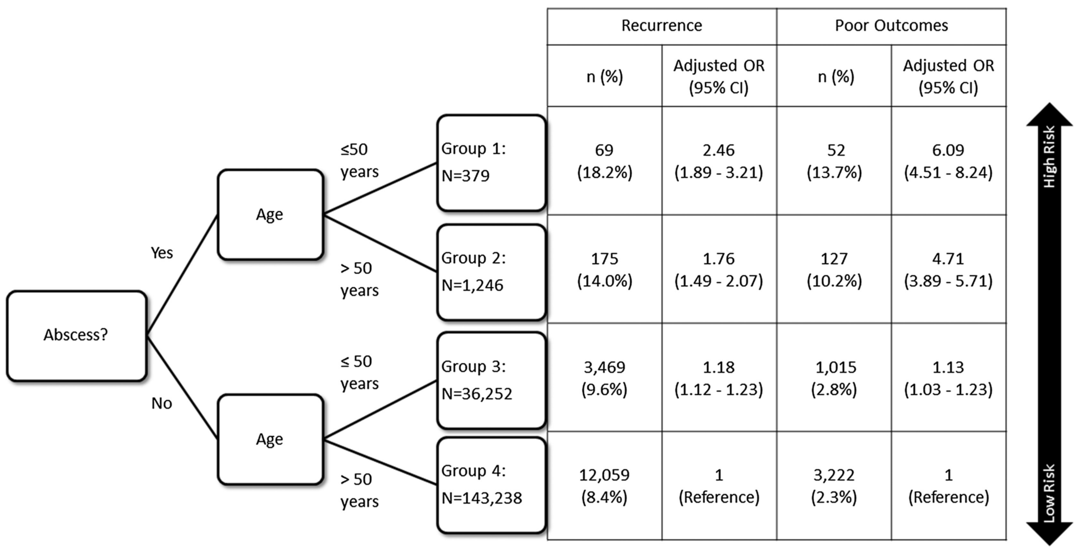

Figure 3. Model 2: risk stratification groups using abscess and age. Adjusted ORs represent logistic regression for patients who were eligible for recurrence, adjusted for year, patient factors (age, sex, comorbidities, median income by zip code, insurance type, and race) and hospital factors (hospital volume by quartile).

emergency surgery or colostomy. In our data, only 2.4% of the patients who recovered from one admission for diverticulitis had a poor outcome. The vast majority of patients in our study had only a single diverticulitis admission captured in our database. However, recurrent episodes posed a risk to patients. Of the patients who were admitted twice, 23% required a third admission; of the patients admitted three times, 37% had four or more admissions.

Modern studies have suggested that morbidity and mortality do not change with a higher number of previous episodes.[7,17] In a study of 137 patients,[17] the incidence of complicated disease and poor outcomes was not different between patients who had one or two episodes when compared with patients who had more than two previous episodes. In our data, once a patient was admitted with recurrence, the incidence of complicated diverticulitis decreased slightly at each subsequent admission: 13% at the first admission, 10.9% at the second admission, and 8.9% at the third admission. However, because the recurrence rate increased with repeated episodes, the percentage of people with poor outcomes among those eligible to recur increased.

Our study has several limitations. Most notably, large administrative databases such as the SPARCS database are limited by the quality of documentation. While SPARCS is robust in size, ICD-9 codes are imperfect and rely on the quality of coding and documentation. Thus, our methodology was meticulous in inclusion/exclusion criteria to exclude any other diagnoses, and we used concrete fields such as "death" whenever possible. We also used procedure codes when possible instead of diagnosis codes because these are likely to be more accurately coded. We cannot be sure that the first episode captured was a patient's first diverticulitis episode or that the last episode captured was a patient's last episode. The interval between admissions for patients with recurrences was short; the mean (SD) time between the first and second captured admissions was 324 (494.83) days. Therefore, it is relatively likely that the "first" admissions captured were truly a patient's "first" admission except in the first 1 year to 2 years of the database.

Another limitation is that there are no follow-up data in our data set on patients who were not readmitted for diverticulitis, and thus, it was not possible to perform a time-to-event data analysis. To analyze the data within data set limitations, we characterized our outcome variables as binary (recurrence/no recurrence or poor outcome/no poor outcome). In addition, we were unable to capture recurrent admissions outside of New York. To reduce this bias, patients who were not New York residents at the time of the first admission were excluded,

TABLE 4. Risk of Recurrence and Poor Outcome for Specific Groups

Risk Group	Comparator Group	OR for Recurrence* (95% CI)	OR for Poor Outcome* (95% CI)
Age ≤ 50 y	Age > 50	1.18 (1.13–1.24)	1.13 (1.04–1.23)
Complicated diverticulitis (any age)	No complicated diverticulitis	1.24 (1.16–1.32)	2.51 (2.30–2.74)
Complicated diverticulitis, age ≤ 50 y	Complicated diverticulitis, age > 50	1.63 (1.40–1.89)	2.95 (2.43–3.58)
Abscess drainage (any age)	No abscess drainage	1.84 (1.60–2.11)	4.89 (4.15–5.76)
Abscess drainage, age ≤ 50 y	Abscess drainage, age > 50	2.27 (1.74–2.95)	5.58 (4.14–7.53)

*Adjusted for year, hospital volume quartile, race, insurance, and income.

although we cannot account for migration to and from New York. We could not account for patient outcomes unrelated to diverticulitis, such as death from other causes. Outpatient cases of diverticulitis could not be evaluated; however, admission is likely a reliable surrogate for clinically relevant disease episodes.

There are many limitations to using a data set that covers such a long period. To minimize the effect of the temporal change on our analysis, all multivariable analyses were controlled for by admission year. The outcomes of interest did not show obvious temporal patterns. The percentage of patients who had a poor outcome was between 1.2% and 2.7% per year, with a peak in 2001, while the percentage of patients who had recurrence was between 4.2% and 10% per year, also with a peak in 2001. Treatment changes, such as conservative management, primary anastomosis for diverticulitis, and laparoscopic colectomy became more common during the study period.[15,18,19] However, the use of laparoscopy for emergent surgery in acute diverticulitis remains low,[20] so we believe that the older data hold relevance and were valuable to capture more recurrences. During the 22-year study, the rate of emergency surgery for diverticulitis did not change dramatically. In 1985, 10.1% of first admissions had emergency surgery; this peaked in 1994 at 13.7% and decreased to 9.2% in 2006. One treatment modality that changed meaningfully during the period of the study was the incidence of abscess drainage. Abscess drainage increased gradually from a low of 0.19% in 1988 to a high of 2.45% in 2006. Although the need for abscess drain was significantly associated with our outcomes of interest, the rate of poor outcomes and recurrences did not have a corresponding increase over time.

Our data are subject to selection bias, as patients who received elective surgery were likely different from patients who did not. In our data, elective surgery rate was relatively low (8.9% after two admissions and 8.8% after three admissions), despite the common teaching at the time that surgery should be offered after two episodes. It is unlikely that all potential surgical candidates received elective surgery, which reduces the effect of the selection bias. Social factors likely to affect disease severity and treatment were immeasurable;[21,22] we attempted to control for some of these factors by including hospital volume quartile, admission years, insurance, estimated patient income, and race/ethnicity.

While recurrence and poor outcomes are difficult to predict, the strongest predictor from the first episode is the presence of complicated diverticulitis; specifically, the need for abscess drainage was the single strongest risk-adjusted predictor of a poor outcome in a subsequent admission (Table 4). Younger patients also have a slightly higher risk of recurrence and poor outcomes; this effect may be caused by longer survival after the initial episode. Current guidelines state that the decision to perform elective surgery should be performed on a case-to-case basis; we hope this study will help clinicians guide their patients to make educated decisions based on their future risk for recurrence and poor outcomes.

Our data suggest that patients with complicated diverticulitis at the first admission, especially those with abscesses, have a high risk of recurrence and poor outcomes and should be offered surgery. In addition, it is reasonable to offer surgery to patients after two admissions or for younger patients, as the chance of readmission or poor outcome is high. Although our data highlight patient groups at higher risk for recurrence and poor outcomes, the baseline risk for recurrence is extremely low. As the vast majority of patients do not have recurrent disease, watchful waiting can be a reasonable option, even for higher-risk patients. It is imperative that patients and clinicians are aware of these risks and carefully consider the risks and benefits of elective surgery.

AUTHORSHIP

V.P.H. performed the data management, data analysis and writing of the manuscript. G.M.N. performed the data acquisition and some statistical analysis, provided guidance for data analysis and data management guidance, and contributed to writing the manuscript. J.W.M. provided overall guidance regarding the direction of the study and edited the manuscript. S.W.L. conceptualized the study and hypotheses, helped with the data acquisition, and wrote and edited of the manuscript.

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DISCLOSURES

The authors declare no conflicts of interest.

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