ORIGINAL ARTICLE

# Risk of Emergency Colectomy and Colostomy in Patients With Diverticular Disease

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**Hypothesis:** Patients with diverticulitis are at a lifetime risk for emergency colectomy and colostomy. Age and recurrence characteristics can serve to predict the risk for these adverse outcomes.

**Design:** Time-to-event analysis and logistic regression were used to determine the risk of emergency colectomy/colostomy.

**Setting and Patients:** A retrospective cohort study using a statewide administrative database and identifying all patients hospitalized nonelectively for diverticulitis (1987-2001).

**Main Outcome Measure:** Emergency colectomy and/or colostomy in patients treated nonsurgically after a first episode of acute diverticulitis.

**Results:** A total of 25 058 patients (mean age [±SD], 69 [16] years, 60% female) were hospitalized for an initial episode of diverticulitis. Of the 20 136 patients treated without initial operation, 19% had recurrences, with younger patients (<50 years) more likely to have a recurrence than older patients (27% vs 17%, $P<.001$). While only 5.5% of patients had recurrent hospitalizations during which an emergency colectomy/colostomy was performed, it occurred more commonly in younger patients (7.5% vs 5%, $P<.001$). The adjusted hazard ratio for emergency colectomy/colostomy in younger patients was 39% higher than in older patients (hazard ratio, 1.39; 95% confidence interval, 1.21-1.62). Among all patients, the adjusted hazard ratio for emergency colectomy/colostomy was 2.2 times higher with each subsequent admission (hazard ratio, 2.2; 95% confidence interval, 2.1-2.2). The predicted probability of emergency colectomy/colostomy was highest in younger patients with multiple rehospitalizations.

**Conclusions:** Age and number of recurrent events were associated with the risk of emergency colectomy/colostomy after successful nonoperative management in patients with diverticulitis. Individualization of recommendations regarding elective colectomy based on these factors may be more appropriate than the application of previously published strategies.

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HALF OF ALL AMERICANS older than the age of 60 years have diverticulosis of the colon and nearly a third of them will develop signs and symptoms of acute diverticulitis.[1] While many episodes of diverticulitis are treated in the outpatient setting, those with advanced disease require hospitalization for intravenous antibiotics, pain control, and management of infectious complications. Patients with peritonitis or perforation frequently require emergency colon resection often including colostomy. In 2001, more than a third of all colon resections and colostomies in the state of Washington were performed for the management of diverticulitis (D.R.F., unpublished data, 2005).

Although most patients hospitalized for diverticulitis do not require immediate surgical resection,[2] they remain at a lifetime risk for both recurrent episodes of diverticulitis and emergency colectomy and/or colostomy. Given the uncertainty of recurrent events and the risk of colostomy, elective colectomy has been recommended for many patients who recover from "nonsurgical" episodes of diverticulitis. Current guidelines suggest elective resection for most patients after the second episode of diverticulitis.[2,3] In younger patients, many advocate elective colon resection after the first episode of diverticulitis because it is more virulent in the young.[4-6] Unfortunately, both recommendations are based on limited data with conclusions extrapolated from small, selected case series; and past practice often guides the decision for elective resection. In fact, fundamental epidemiologic features of adverse outcome in patients with diverticulitis have yet to be

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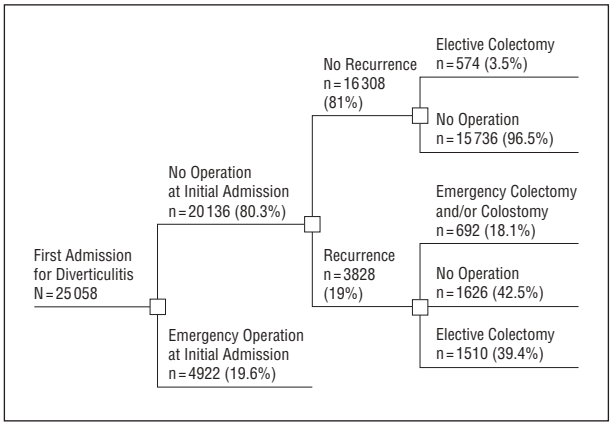


**Figure 1.** Diverticulitis management in Washington state (1987-2001).

established and even the basic consideration that age is an important predictor of outcome has been challenged by several recent reports.[7,8] Furthermore, treatment recommendations to date may not reflect the actual risk of recurrence, emergency colectomy and/or colostomy in the general population because the data they were derived from are subject to both selection and publication bias. As a result, clinicians have been unable to provide meaningful risk estimates when counseling patients who have recovered from an episode of diverticulitis.

The purpose of this study was to quantify the population-level risk of emergency colectomy and/or colostomy in patients with diverticular disease and to determine the patient characteristics associated with these adverse outcomes. Specifically, we aimed to evaluate the relationship between age and recurrent events, and its influence on the risk of adverse outcome.

## METHODS

A retrospective cohort study was conducted using a statewide, hospital discharge database, the Washington State Comprehensive Hospital Abstract Reporting System (CHARS). This data set is derived from all public and private hospitals in Washington state (Veterans Affairs and US military hospitals excluded) and contains demographic variables, admission and discharge administrative details, *International Classification of Diseases, Ninth Revision* (*ICD-9*) procedure and diagnosis codes, and coded hospital identifiers. The CHARS records were linked to the Washington State Department of Health Vital Statistics Database to identify patients who died during the follow-up period. This study was exempted from human subjects review by agreement of the University of Washington Human Subject Review Committee and the Washington State Department of Health.

### SUBJECTS

The cohort was defined by searching all CHARS reports (1987-2001) for *ICD-9* diagnostic codes pertaining to diverticulitis (56 211 or 56 213). Patients under the age of 18 years whose initial diverticulitis admission was for an elective procedure and those who also had the diagnosis of colon cancer were excluded.

### VARIABLE DEFINITION

The administrative designation of admission type was used to classify admissions. Patients whose initial admission was characterized as "emergent" or "urgent" were considered in the analysis. When those patients also had concurrent *ICD-9* procedure codes for colectomy (*ICD-9* procedure codes 458, 4573, 4574, 4575, 4576) and/or colostomy (*ICD-9* procedure codes 461, 462), they were considered to have had "emergency" procedures. Those who did not undergo emergency procedures on their first admission for diverticulitis were defined as "nonsurgically" treated. Patients were tracked through time by their unique, coded patient identifier, and admissions for *ICD-9* diagnostic codes pertaining to diverticulitis were considered recurrent events. Abscess (*ICD-9* diagnostic codes 5672, 5695, or procedure codes 8838, 5491) and fistula (*ICD-9* diagnostic codes 6869, 56 981, 5962, 6192, 6191, 5374, 59 382, 5961, 6199, 5672, 28 959) were defined using *ICD-9* codes.

Previous investigators have considered young patients with diverticulitis to be either younger than 40[9] or younger than 50.[10] To best determine a reasonable cut off for "younger" patients, we compared those younger than 40 years old with those 40 to 50 years and found few differences in clinical features between those younger than 40 years and those between 40 and 50 years old. For that reason, "younger" patients in this study were defined as those younger than 50 years of age. In the logistic regression model, age was also considered as a continuous variable. A modified Charlson Comorbidity Index[11] (0-3, with 3 indicating greatest comorbidity) was calculated for each patient based on *ICD-9* diagnostic codes.

Adverse outcome was defined as an emergency colectomy and/or colostomy without antecedent elective colectomy in the 30 prior days. In-hospital and 30-day death were considered secondary adverse outcomes. We assessed the degree to which emergency colectomy was an adverse outcome by comparing the rate of colostomy use and 30-day mortality with emergency and elective colectomy.

### ANALYSIS

Descriptive and comparative statistics were applied using STATA version 7 (STATA Corp, College Station, Tex). Categorical variables were compared using Pearson $\chi^2$ statistic and continuous variables were evaluated using analysis of variance. A $P$ value of less than .01 was considered statistically significant.

Kaplan-Meier survival estimates were used to determine the proportion of patients who underwent emergency colectomy and/or colostomy over time. The median time of risk was 4.3 years (mean, 5.5 years, range, 0-16.6 years, with 25% followed for at least 8.5 years). Log-rank and Wilcoxon rank sum testing were used to compare unadjusted survival estimates for younger patients with those of older patients and to evaluate the equality of survival curves.

Cox proportional hazards were used to simultaneously control for multiple covariates and determine: 1) the hazard ratio of emergency colectomy and/or colostomy, and 2) the hazard ratio of recurrent admission based on whether the patient was considered "younger." Cox regression was performed with variables of interest: younger patients in an unadjusted model, models that adjusted for patient variables, and patient and hospital variables. Separate Cox regression models of this type were established for the outcome of emergency colectomy and/or colostomy, and recurrent admission. The proportional hazards assumption for both the model with the outcome emergency colectomy and/or colostomy and the one with recurrence as the outcome was confirmed by inspecting Schoenfeld residuals. All reported hazard ratios were adjusted for patient and hospital characteristics.

The predicted probability of adverse outcome (emergency colectomy and/or colostomy) based on patient age was determined using a multivariate logistic regression model with age as a predictor of outcome, and sex and comorbidity index con-

**Table 1. Markers of Disease Aggressiveness and Outcomes in Patients With Diverticulitis Initially Treated Without Surgery by Age Category***

| Variables | All Patients (N = 20 136) | Age Group <40 y (n = 1244) | Age Group 40-50 y (n = 2726) | Age Group >50 y (n = 16 166) | *P* Value |
|---|---|---|---|---|---|
| Clinical characteristics | | | | | |
| Recurrent admission | 19 | 27.7 | 26.12 | 17.14 | <.001 |
| More than 1 recurrent admission | 3.8 | 6.0 | 5.0 | 3.5 | <.001 |
| Abscess | 7.4 | 11.2 | 11.7 | 6.4 | <.001 |
| Fistula | 2.5 | 2.7 | 3.0 | 2.4 | .1 |
| Adverse outcome | | | | | |
| Recurrence resulting in emergency colectomy | 4.4 | 6.7 | 5.8 | 4.0 | <.001 |
| Colostomy | 2.3 | 2.4 | 2.9 | 2.2 | .06 |
| Emergency colectomy and/or colostomy | 5.5 | 7.5 | 7.3 | 5.0 | <.001 |
| In-hospital death | 1.5 | 0 | 0.3 | 1.8 | <.001 |
| 30-day mortality | 2.7 | 0 | 0.3 | 3.4 | <.001 |

*Values are expressed as percentages unless otherwise indicated.

sidered as covariates. Clustering on the hospital level was used to adjust for similarities of patients in different hospitals.

## RESULTS

### DESCRIPTIVE ANALYSIS

In the state of Washington between 1987 and 2001, a total of 25 058 patients (mean age [±SD], 69 [16], 60% female, mean Charlson Index score [±SD], 0.44 [0.75]) were admitted emergently or urgently for initial episodes of diverticulitis. Of these, 19.6% underwent operative intervention during that initial admission while the remainder had nonoperative management. Only 19% of patients undergoing initial, nonoperative management had recurrent admissions for diverticulitis (**Figure 1**). Patients with recurrent admissions after initial nonoperative management were younger than those without recurrent disease (62 [15.9] vs 71 [16]) years, $P<.001$), but otherwise had similar demographic characteristics. Of the 19% who had recurrent disease, 18.1% had emergency colectomy and/or colostomy, while 39.4% had an elective colectomy and 42.5% had no operative intervention.

Emergency operations were associated with worse outcomes when compared with elective procedures. For example, 56% of patients undergoing emergency surgery at initial admissions had a colostomy compared with only 15% of patients undergoing elective colectomy at initial admission ($P<.001$). Similarly, 30-day mortality was 3.1% for emergency cases compared with 1.1% ($P<.001$) in those undergoing elective procedures.

Clinical characteristics as well as adverse outcomes varied by patient age group (**Table 1**). Patients younger than 40 years had similar features compared with patients 40 to 49, and both of these younger groups differed significantly from those older than 49 in clinical characteristics and outcome. While emergent/urgent surgical resection during the initial hospitalization was noted in 19.6% overall, the rate was slightly higher in those younger than 40 years (22.6%) as well as those aged 40 to 49 years (23.1%) compared with 18.8% of patients over the age of 50 years ($P<.001$). Younger patients had a higher rate of readmission for diverticulitis (26%-27% vs 17%, $P<.001$), a higher rate of multiple admissions (5%-6% vs 3.5%, $P<.001$), and higher rates of abscesses (11.2%-11.7% vs 6.4%, $P<.001$) compared with older patients. Patients younger than 50 years were more likely to have had emergency colectomy and/or colostomy (7.3%-7.5% vs 5.0%, $P<001$), but 30-day mortality was lower (0%-0.3% vs 3.4%, $P<.001$) in the younger group.

**Table 2. Hazard Ratio for Adverse Events in Younger Patients Who Do Not Require Surgery at First Admission***

| Model | Recurrence After First Event HR (95% CI) | Emergency Colectomy and/or Colostomy HR (95% CI) |
|---|---|---|
| Model 1 | | |
| Younger patients | 1.53 (1.42-1.64) | 1.39 (1.21-1.59) |
| Model 2 | | |
| Younger patients controlling for patient features† | 1.46 (1.35-1.57) | 1.35 (1.17-1.56) |
| Model 3 | | |
| Younger patients controlling for patient features and hospital variables‡ | 1.46 (1.35-1.58) | 1.39 (1.21-1.62) |

Abbreviations: CI, confidence interval; HR, hazard ratio.
*Based on a total population of 20 136 patients. Younger patients are defined as those younger than 50 years.
†Sex, comorbid illnesses, and abscess at initial presentation.
‡Rural, teaching, for profit status.

### TIME-TO-EVENT ANALYSIS

After adjusting for patient age, sex, and Charlson index, the adjusted hazard ratio for recurrent hospitalizations for diverticulitis was 46% higher (hazard ratio [HR], 1.46; 95% confidence interval [CI], 1.35-1.58) for patients younger than 50 years compared with older patients (**Table 2**). The adjusted HR for emergency colectomy

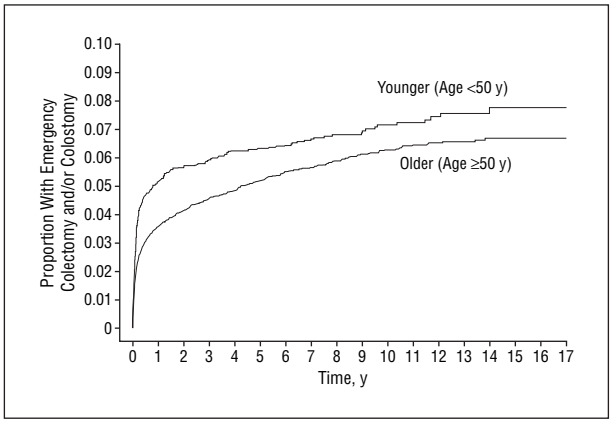


**Figure 2.** Proportion of patients with either emergency colectomy and/or colostomy, by age group over time, $P<.001$.

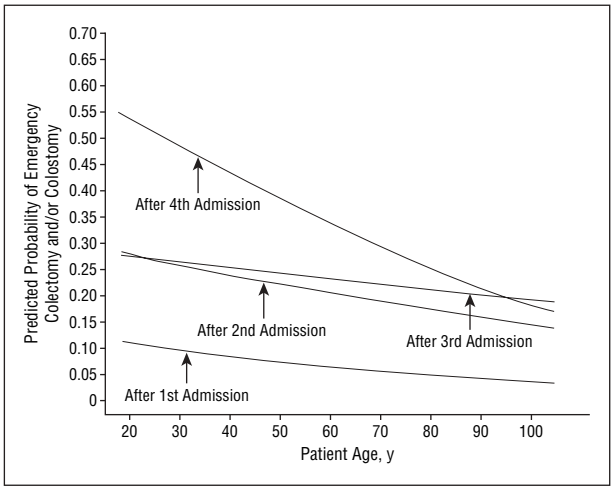


**Figure 3.** Predicted probability of adverse outcome (emergency colectomy and/or colostomy) with increasing age, by number of admission.

and/or colostomy was 39% higher (HR, 1.39; 95% CI, 1.21-1.62) for those younger than 50 years even when adjusting for important patient and hospital characteristics. The adjusted HR of undergoing an emergency colectomy and/or colostomy was more than double for each recurrent admission for diverticulitis than the admission preceding it (HR, 2.2; 95% CI, 2.1-2.2). While the risk of emergency colectomy and/or colostomy increased with time after initial admission for all patients (**Figure 2**), differences in the HR based on age group ($P<.001$) were most evident in the first few years after initial hospitalization and then appeared to be minimal.

When age was considered as a continuous variable using logistic regression, for each increase in age by 1 year, the odds ratio (OR) of emergency colectomy and/or colostomy decreased by 2% (adjusted OR, 0.98; 95% CI, 0.98-0.98). Based on this relationship of patient age and adverse outcome, the predicted probability of emergency colectomy and/or colostomy was determined for patients after the first hospitalization and at subsequent hospitalizations (**Figure 3**). For example, patients with a single admission for diverticulitis that were older than 50 years had an approximately 5% predicted probability over time of undergoing emergency colectomy and/or colostomy. Conversely, very young patients (for example, those <30 years of age after 4 admissions) were at approximately 50% risk.

## COMMENT

To our knowledge, this is the first population-based evaluation of the risk over time of emergency colectomy and/or colostomy in patients hospitalized with diverticulitis, and describes several fundamental epidemiologic issues in diverticular disease. This study found that only a small percentage (5.5%) of patients who recovered from an initial episode of nonsurgical diverticulitis ever required emergency colectomy/colostomy. While that proportion was also low in younger patients (7.5%), the HR of those events over time was significantly higher (approximately 40% greater) than in older patients. Using predicted probability, the estimated risk of colectomy and/or colostomy for patients at any age and number of recurrent episodes was determined.

In 2000, a report by the Standards Task Force of the American Society of Colon and Rectal Surgeons[2] recommended elective colectomy after 2 attacks based primarily on data from the 1960s[12] demonstrating that subsequent attacks of diverticulitis were less likely to respond to medical therapy. The report did not detail practice parameters for the treatment of young patients with diverticulitis, rather it noted that although some surgeons recommend elective resection in young patients after 1 well documented episode, it remains controversial because the natural history in the young patient has not been clearly defined. This tenet may have developed because multiple investigators reported small case series detailing a more virulent course in younger patients,[13,14] with operation necessary in up to 88% of the cases during the first episode of diverticulitis.[5,13,15] Others have argued that if not more aggressive initially, the recurrence rate may be significantly higher in younger patients.[6,14,16,17] For example, a study by Chodak et al[5] showed that 73% of patients younger than 40 years with diverticulitis underwent surgery during a 14-year period and that 50% of those initially treated without surgery ultimately progressed to colectomy (28% of which were emergent). However, several recent studies have failed to demonstrate that diverticulitis in the young is a more virulent process and challenge the recommendation of intervention after an initial event.[7,8,18,19] Others have found that rather than being a more aggressive variant, younger patients undergoing emergent operations were frequently misdiagnosed preoperatively (25%-50% of cases) and might not have needed intervention at all given better diagnostic evaluations.[7,18] Our finding of a low absolute rate of emergency colectomy/colostomy in the setting of a higher relative rate of this outcome in younger patients may explain the varied results found in prior studies. Undoubtedly, prior studies in this area have been limited by their small sample size. Given the low rate of this outcome, these prior studies are highly susceptible to type II error. For example, to detect a rate difference of 7.5% vs 5% in this outcome requires approximately 2000 patients in each arm of a randomized trial.

In demonstrating an independent, continuous relationship between age of the patient and outcome, this

study should help clinicians counseling patients across the spectrum of age groups. Specifically, we found that 73% of young patients have no recurrences and of the minority that do, most resolve without any surgical intervention. In fact, approximately 7% of all patients younger than 50 years ever require emergency colectomy/colostomy. This rate is significantly lower than that identified in small case series[5] and does not support the practice of elective surgical intervention in young patients after an initial episode. In fact, this study demonstrates that a policy of routine, elective colectomy in the younger population would direct approximately 13 patients toward elective surgery to prevent emergency colectomy and/or colostomy in 1 patient. Similarly, these data challenge the recommendation of the American Society of Colon and Rectal Surgeons to perform elective colectomy after the second hospitalization in all patients and reinforce a recent modeled analysis demonstrating that for the average patient performing surgery earlier than the third attack does not increase life expectancy or quality-adjusted life-years.[20] Our study supports the individualization of operative decision making based on the patient's age- and recurrence-specific risk of emergency colectomy/colostomy.

This study has several limitations. Selection bias may have been introduced by including only those patients who were initially hospitalized for diverticulitis. In doing so we excluded patients with diverticulitis who were treated as outpatients and so the designation of "initial diverticulitis event" may have limited generalizability. It is unclear if inclusion of patients treated as outpatients would have effected our findings regarding age. Similarly, the first episode was considered to be the first after 1986. Patients hospitalized before 1987 may be misclassified regarding initial admission, but this would likely represent a conservative bias given the identified association between recurrent admissions and outcome. The threshold for hospitalization may have changed over time and with the emergence of better oral antibiotic options. We did attempt to control for changes over time by introducing year of admission in the regression model, but found it had little impact on the model. Changes in the threshold for both emergency colectomy and the use of colostomy may have also changed over time or by patient type. One way in which the threshold for intervention might have impacted our results is if surgeons had performed nonelective colectomy more often in younger patients because of a belief that the hospitalized younger patient should undergo colon resection prophylactically at that visit. To address this, we confirmed that emergency colectomy was indeed a different operation than elective colectomy and found a much higher risk of both death and stoma use in nonelective procedures.

This study demonstrates the population-level probability of emergency colectomy and/or colostomy for patients of different ages and based on the number of prior hospitalizations for diverticulitis. Younger patients and those with multiple prior attacks are at greatest risk for emergency colectomy and/or colostomy. However, given that most young patients will not have a recurrent episode of diverticulitis and that only 7.5% will require an emergency operation or colostomy, elective colectomy after initial hospitalization does not appear to be warranted. This information provides the opportunity for age-specific determinations of risk and should inform decisions about when to intervene surgically. These data should help those considering management options after being diagnosed with diverticulitis and in the development of treatment recommendations based on outcome, cost, and quality of life.

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