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Long-Term Outcomes of Patients with Non-Surgically Managed Uncomplicated Appendicitis

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Abstract

Background—Emerging literature has supported the safety of non-operative management of uncomplicated appendicitis.

Study Design—Patients with emergent, uncomplicated appendicitis were identified by appropriate ICD-9 diagnosis codes in the California Office of Statewide Health Planning and Development (OSHPD) database from 1997 to 2008. Rates of treatment failure, recurrence, and perforation following non-surgical management were calculated. Factors associated with treatment failure, recurrence, and perforation were identified using multivariable logistic regression. Mortality, length of stay, and total charges were compared between treatment cohorts using matched propensity score analysis.

Results—Among 231,678 patients with uncomplicated appendicitis, the majority (98.5%) were managed operatively. Among the 3,236 non-surgically managed patients who survived to discharge without an interval appendectomy, 5.9% and 4.4% experienced treatment failure or recurrence, respectively, over a median duration of follow up of greater than seven years. There were no mortalities associated with treatment failure or recurrence. The risk of perforation after discharge was approximately 3%. Using multivariable analysis, race and age were significantly associated with the odds of treatment failure. Gender, age, and hospital teaching status were significantly associated with the odds of recurrence. Age and hospital teaching status were significantly associated with the odds of perforation. Matched propensity score analysis indicated that after risk adjustment mortality rates (0.1% vs. 0.3%, $p=0.65$) and total charges (\$23,243 vs. \$24,793, $p=0.70$) were not statistically different between operative and non-operative patients, however, length of stay was significantly greater amongst the non-operative treatment group (2.1 vs. 3.2 days, $p<0.001$).

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Conclusions—This study suggests that non-operative management of uncomplicated appendicitis may be safe, and prompts further investigations. Comparative effectiveness research using prospective randomized studies may be particularly useful.

INTRODUCTION

Surgical management is currently the mainstay for treating patients presenting with acute uncomplicated appendicitis. With nearly 300,000 appendectomies performed annually in the United States, surgical management of appendicitis represents a substantial source of both direct healthcare expenditures and indirect social costs(1, 2).

While appendectomy is safe and offers the benefit of being a definitive treatment, it carries some risk of morbidity including ileus, adhesions, and infection. The inherent trade-off between a definitive treatment and the risk of post-surgical complications has historically favored surgical management, in part, because of a commonly held assumption that progression to perforation is essentially inevitable(3). However, epidemiological studies(4) and basic science research(5) have provided evidence that perforated and non-perforated appendicitis are pathophysiologically distinct entities. Further work has suggested that non-perforated appendicitis may behave similarly to non-perforated diverticulitis and thus may have no added risk of progressing to perforation(1, 2).

As such, the objective of this study was to assess the rates of treatment failure, recurrence, post-discharge perforation, mortality, total charges, and length of stay in the current non-operative management of uncomplicated appendicitis. Given the low frequency of non-operative management in the current treatment of uncomplicated appendicitis, a large longitudinal administrative database was chosen to obtain a sufficient sample of patients.

METHODS

Inclusion and Exclusion

This study was conducted and is reported based on recommendations of the STROBE statement(6). Retrospective analysis was conducted using data from the California Office of Statewide Health Planning and Development (OSHPD) Patient Discharge. Data on patient admissions were available from 1995–2010. This database captures 100 percent of admissions in California acute care hospitals. Patients were included if they carried an ICD-9 diagnosis code of 540.9 (“acute appendicitis without mention of peritonitis, perforation, or rupture”) listed as any one of the diagnosis codes associated with their admission between 1995 and 2008. In OSHPD, each patient may have up to 25 diagnosis codes for each admission with one code identified as the primary diagnosis. Patients were not included if their initial admission occurred in 2009 and 2010 in order to allow for at least two years of follow up for patients presenting as late as 2008. Patients were then classified into surgical and non-surgical cohorts according to whether they had a procedure code indicating appendectomy (47.01, 47.09).

Patients were excluded (Figure 1) if their first admission occurred within a two-year period from 1995 to 1996 at the beginning of data collection. With this exclusion criteria patients

included in this study were known to have a disease free interval for at least two years prior to the study. This was done to mitigate the possibility that the first identified episode of appendicitis within the database represented a recurrent admission subsequent to a prior instance of appendicitis before data collection was initiated. Without this exclusion criterion a patient who was initially admitted in 1994 for an episode of appendicitis and subsequently experienced a recurrence in 1995 would be incorrectly identified as a primary admission. Therefore, enrollment for patients with an index appendicitis admission and a known disease free period of two years occurred from 1997–2008. Follow-up continued throughout 2010.

Patients were further excluded from analysis if their first admission for appendicitis was categorized as “scheduled” according to OSHPD coding because of concerns that the admission was merely follow-up for a previous appendicitis episode. Patients were also excluded in instances where a code for appendiceal abscess (540.1), ruptured appendicitis (540.0) or drainage of appendiceal abscess (47.2) was present on the initial admission. These exclusions were applied to limit the study to those with uncomplicated cases of appendicitis.

Patient and Hospital Characteristics

Patient demographic and hospital information was obtained from data provided within the OSHPD database. Information was provided on patient insurance coverage, race, gender, age, and year of admission. Patient insurance status was defined as “Medicaid” if patients were covered by Medi-Cal, “workers compensation”, “county indigent program”, “other government”, or “other indigent” insurance status according to the payer variable as coded by OSHPD. Charlson Index was calculated to assess patient comorbidities using the method established by Romano and colleagues(7). Hospitals were classified as teaching or non-teaching according to whether or not they maintained a general surgery residency program.

Outcomes

Rates of treatment failure, recurrence, and perforation were the primary outcomes of interest for this study. Treatment failure was defined as a subsequent readmission for any form of appendicitis (540.0, 540.1, 540.9, 541, 542), drainage of appendiceal abscess (47.2), or appendectomy (47.01, 47.09) within 30-days of admission. Recurrence was defined as a subsequent admission for any form of appendicitis, drainage of abscess, or appendectomy any time after 30 days following discharge. The 30-day distinction between treatment failure and recurrence was chosen to reflect the increasing importance of 30-day readmission in the current health policy landscape. Amongst those with treatment failure and recurrent admissions, patients were classified as “perforated” or “non-perforated” based on whether they had a diagnosis code for appendicitis with abscess or rupture, or a procedure code indicating drainage for abscess.

To mitigate the possibility that results were biased by the presence of misdiagnoses, sensitivity analyses were completed by assessing treatment failure, recurrence, and perforation in subsets of patients with confirmed CT abdominal imaging (88.01) and a *primary* diagnosis code of “acute appendicitis without mention of peritonitis, perforation, or rupture” (540.9).

Cost, length of stay, in-hospital and 30-day mortality rates were also assessed as secondary outcomes. Total charges and length of stay were recorded for each admission within the OSHPD database. 30-day mortality was defined as death occurring within 30 days of discharge. Information regarding death was ascertained by the Social Security Death Index which was linked to OSHPD records. For those patients who died after 1998, cause of death was specified within OSHPD. This information was subsequently used to determine whether death was attributed to disease of the appendix.

Given the potential for selection bias in the assignment of patients into operative and nonoperative cohorts, a “nearest neighbor” propensity score matched algorithm(8) was used to assess the effect of treatment on patient mortality, cost, and length of stay. This method was chosen to “virtually randomize” patients into treatment cohorts with similar baseline characteristics(9). Propensity scores represent the predicted probability that a patient will receive treatment when risk-adjusted for variables of interest. Propensity scores were generated using a multivariable logistic regression model adjusting for Charlson Index, teaching status of the treating institution, patient insurance status, gender, age, race, and year of admission. Each nonoperative patient was then matched to an operative patient with the nearest propensity score. Outcomes of interest were then compared between the matched cohorts.

Statistical Analysis

Statistical analysis was performed using commercially available software (Intercooled STATA SE Version 11.2; Stata Corp LP, College Station, Texas). Matched propensity score analysis was completed using a commercially available software module(8). All relevant clinical and demographic variables available in the OSHPD database were included in the logistic regression models. These included patient insurance status, race, gender, hospital teaching status, Charlson Comorbidity Index, age, and year to assess factors associated with treatment failure, recurrence and perforation. Statistical significance was defined as $p < 0.05$.

RESULTS

A total of 231,678 patients with acute uncomplicated appendicitis were identified within California from 1997–2008 (Table 1). The vast majority of these patients (98.5%) were managed with appendectomy. Most (68.9%) were insured with either Medicare or Private insurance. The population of interest was relatively young with a mean (standard deviation) age of 32.4 (17.0) years. The majority of patients identified were White (51.5%), and also male (55.9%). Patients were also relatively healthy with a mean (SD) Charlson Index of 0.16(0.6). The observed in-hospital mortality rate was 0.1% with a 30-day mortality rate of 0.1% for those discharged from care. The mean (SD) time to all-cause death for patients who died at any point following discharge from index appendicitis admission was 4.1 (3.0) years. For patients who died within 30-days of discharge, the mean (SD) time to death was 15.1 (8.8) days. The mean (SD) length of stay and total charges for all patients was 2.1 (2.9) days and \$23,300 (\$33,600), respectively. Most patients (91.1%) were seen at a non-teaching institution.

Significant differences in patient characteristics were observed between non-operative and surgical cohorts (Table 1). A greater proportion of surgical patients were covered by Medicare or private insurance (69.0% vs. 65.0%, $p<0.001$). The non-operative cohort tended to be older with a mean age of 41.0 years compared to 32.3 years for surgical patients ($p<0.001$). Moreover, the non-operative cohort consisted of relatively more females (51.1% vs. 44.0%, $p<0.001$). The non-operative cohort presented with greater baseline illness when assessed by both the mean Charlson Index (0.60 vs. 0.15, $p<0.001$) and the proportion of patients with a Charlson Index of three or more (9.2% vs. 1.5%, $p<0.001$). The rate of death within 30 days of discharge was higher amongst non-operative patients (1.0% vs. 0.1%, $p<0.001$). The unadjusted mean length of stay was significantly greater for non-operative patients (4.4 vs. 2.1 days, $p<0.001$). The unadjusted mean total charges was also significantly greater amongst nonoperative patients (\$36,200 vs. \$23,200, $p<0.001$).

Unadjusted in-hospital mortality was found to be significantly greater amongst the non-operative cohort (1.5% vs. 0.1%, $p<0.001$). When cause of death was analyzed amongst non-operative patients, one case was attributed to disease of the appendix (Table 2). Most deaths in the non-operative cohort were attributed to chronic conditions (57.5%) or malignancy (15%). When compared between operative and non-operative patients, rates of death associated with disease of the appendix were not statistically different (0.03% vs. 0.01% $p=0.06$).

Non-operative patients were followed over time for a mean duration of greater than seven years (SD 3.9 years) to determine the rates of treatment failure, recurrence, and perforation (Figure 2). On examination, a small minority of non-operative patients either died during their hospital admission (1.5%), or were scheduled for an interval appendectomy recorded on a separate admission (2.5%), and were censored. Of the remaining non-surgically managed patients ($n=3,236$), a minority experienced either treatment failure (5.9%) or a recurrent episode of appendicitis (4.4%). The mean (SD) time to treatment failure and recurrence was 5.9 (7.1) days and 1.9 (2.4) years, respectively. There were no deaths in patients with treatment failure or recurrent admissions. Amongst those with treatment failure, 70.3% returned without mention of perforation or abscess. For patients with a recurrent episode, 66.4% returned without perforation or abscess. Therefore, the cumulative risk of perforation following discharge for an initial admission of uncomplicated appendicitis was 3.2%.

Results of the multivariable logistic regression models indicated that patient race and age were each independently associated with a non-operative patients' odds of treatment failure (Table 3). Relative to White patients, Asian and Pacific Islanders were associated with a reduction in the odds of treatment failure (OR 0.52, 0.27–0.97). Patients between the ages of 20 and 69 were associated with reductions in the odds of treatment failure relative to those between the ages of 0 and 9. Patient insurance status, gender, comorbidities, and hospital setting were not associated with treatment failure.

Patient age, gender, and hospital teaching status were independently associated with recurrence on multivariable logistic regression analysis. Female patients were associated with a reduction in the odds of recurrence relative to their male counterparts (OR 0.70, 0.50–

0.99). Patients 10 years of age and older were associated with increases in the likelihood of recurrence relative to those less than 10. In all age cohorts greater than the age of 9, there was a trend towards an increased odds of recurrence. However, this was only significant for patients between the ages of 10–19, 40–49, 60–69, and those greater than the age of 90. Patients who were seen at a teaching institution were associated with an increase in the odds of recurrence relative to patients from non-academic hospitals (OR 2.15, 1.40–3.31). Insurance status, race, and Charlson Index were not statistically significant in the multivariable model.

A third multivariable analysis demonstrated that patient age and hospital teaching status were independently associated with a non-operative patient's odds of perforation (Table 3). Relative to patients aged 0–9, those aged 20–29 were associated with a reduction in the odds of perforation (OR 0.31, 0.12–0.85). Patients from teaching institutions were associated with more than a two-fold increase in the odds of perforation (OR 2.28, 1.38–3.78). Patient insurance status, race, gender, and Charlson Index were not significantly associated with perforation.

To mitigate the possibility that cases of non-operative appendicitis identified in this study represented misdiagnoses of other disease processes, sensitivity analysis was conducted on the rates of treatment failure, recurrence, and perforation. When analysis was restricted to patients with a primary diagnosis of uncomplicated appendicitis, the rate of treatment failure was 7.5%. The rate of recurrence calculated for these patients was 5.7% while the rate of perforation was 4.2%. A second sensitivity analysis was conducted on patients with a confirmed CT abdominal scan. The rate of treatment failure for patients with a confirmed CT abdominal scan was 5.0%. The rate of recurrence for these patients was 5.9% and the rate of perforation was 2.9%. In summary, rates of treatment failure calculated in both sensitivity and original analyses for all non-operative patients ranged from 5.0%–7.5%. The rates of recurrence ranged from 4.4%–5.9% and rates of perforation ranged from 2.9–4.2%.

Mortality, length of stay, and total charges were compared between operative and non-operative patients matched on the basis of propensity score of treatment. When matching was completed, the rates of in-hospital mortality between operative and non-operative patients were similar (0.1% vs. 0.3%, $p=0.65$). 30-day mortality was not statistically significant between the two treatment cohorts (0.1% vs. 0.3%, $p=0.67$). Mean total charges were not statistically different between the matched treatment cohorts (\$23,243 for operative patients vs. \$24,793 for non-operative patients, $p=0.70$). Non-operative patients were associated with a longer mean length of stay (2.1 vs. 3.2 days, $p<0.001$).

DISCUSSION

This report represents the largest longitudinal population-based study of outcomes for non-operatively managed patients with uncomplicated appendicitis for a mean duration of follow-up of greater than seven years. It reveals that the majority of patients with uncomplicated appendicitis undergoing non-surgical management do not experience treatment failure or a recurrent episode of appendicitis. When patients did have a treatment

failure or recurrent episode, most were readmitted without perforation or abscess, and none died during their readmission.

When patients were matched with regard to propensity score of operative management, mortality rates and total charges were similar between the two treatment groups. The increased rates of mortality and total charges observed on unadjusted analyses were likely the result of selection bias and the confounding effect of baseline illness. Given the preeminence of surgical management, patients selected into the non-operative cohort may have been poor surgical candidates with reduced life expectancy. Our analysis, for example, demonstrated that non-operative patients presented with a greater number of comorbidities at baseline. Additionally, our mortality analysis confirmed that the observed mortality difference between operative and nonoperative patients was not attributed to appendicitis, but rather due to chronic disease and/or malignancy. Moreover, the absence of treatment effect on mortality is consistent with literature which has long demonstrated that the mortality from appendicitis is essentially nonexistent in non-perforated cases(10).

These results suggest that the risks and benefits of operative management of nonperforated appendicitis may need to be reconsidered. The risk of postoperative complication following surgery is not insignificant; occurring in 2–23% of cases(11). Other reports have suggested that there is at least a three-fold increase in major complications associated with surgery relative to antibiotic treatment(12).

This study also suggests that non-operative management may have inadequacies in the treatment of appendicitis. Amongst these are the increased length of stay and increased treatment failure (defined as 30-day readmission) associated with non-operative management. While the rate of treatment failure was 5.9% in non-operative patients, it was only 0.1% in operative patients. With concerns over controlling 30-day readmission and rising healthcare costs, these shortcomings may be substantial barriers to the consideration of non-operative approaches. With that said, it is possible that these differences are confounded by baseline illness that could not be accounted for using the variables available in the OSHPD database.

This study also noted that female patients were less likely to experience a recurrent admission for appendicitis relative to their male counterparts. While this study is unable to determine the mechanism behind this association, the difference between males and females may be due to a higher rate of misdiagnosis in the female population. However, this mechanism should also result in a reduced rate of treatment failure, which was not observed. Therefore, physiologic differences with regard to patient gender may also need to be considered in future work.

This study has all the limitations traditionally associated with administrative databases. Though there is high fidelity in operative billing data, it may be questionable whether non-operative patients truly experienced an episode of appendicitis rather than a misdiagnosis of another etiology of acute abdomen. A high rate of misdiagnosis, in turn, could artificially reduce the rates of treatment failure, recurrence, and perforation identified in this study. Given the absence of more specific clinical data (e.g. detailed imaging reports), it is

impossible to precisely determine the rate of misdiagnosis. However, when analysis was limited to those least likely to have a misdiagnosis (those with a primary diagnosis code for uncomplicated appendicitis and those with an abdominal CT), the results were similar. Moreover, previous literature has established negative appendectomy rates ranging from 9–20% for all patients(13–16), and 4–8% in those with CT imaging(15–17). Even under a conservative scenario in which misdiagnosis occurred in 20% of cases, the perforation rate observed in this study would only increase to 4.0%. Therefore, while misdiagnosis is a real clinical problem, it is unlikely to have a meaningful impact on the presented results.

This study is also limited in its ability to understand why patients were selected in to one treatment group versus another. The use of a propensity score matched algorithm, however, allowed for analysis to be conducted on patient populations that were similar with regard to the available variables in the OSHPD database.

Despite its limitations, the OSHPD database represents a particular strength of this study because it provides a 100 percent patient sample across a large state for more than 10 years. Given the low frequency of non-operative management in the current treatment of appendicitis, it is difficult to answer questions regarding this controversy without a large sample to provide sufficient power. By providing an observation period from 1997–2010, this study followed patient recurrence for a greater duration than most previous work. Though the data is specific to the state of California, the findings provide meaningful information to the growing body of literature assessing the non-operative management of uncomplicated appendicitis because of the state's large, heterogeneous population. While a randomized trial would certainly be of benefit, any such trial will have its own limitations. Randomized trials are generally limited in terms of cost and questions of generalizability beyond the institution conducting the study. Randomized trials are also typically associated with concerns of whether findings are generalizable beyond the inclusion criteria used to recruit patients.

Future studies should elucidate if specific treatment regimens allow for safe and efficacious non-operative management. They should also define specific criteria for safely selecting patients for non-surgical management. The APPAC trial was recently initiated in Finland in order to provide level 1 evidence to the hypothesis that at least 75% of patients with uncomplicated appendicitis can be managed effectively with antibiotics(18). Another study has demonstrated a 93.7% success rate in the non-operative management of pediatric patients by limiting non-operative management to patients with hemodynamic stability, a history lasting less than 24 hours, and without signs of peritoneal irritation, necrosis or appendicolith(19). Criteria such as these need to be rigorously studied and validated to ensure patient safety.

Conclusion

The likelihood of presenting with a subsequent episode of perforated appendicitis following initial non-surgical management may be low enough to question the perceived risks associated with non-operative management of uncomplicated appendicitis. This is further reinforced by similar mortality rates between propensity score matched treatment cohorts as well as the absence of deaths during readmission. Future studies can build on this work by

assessing the comparative effectiveness of surgical vs. non-surgical management in a randomized trial, designing optimal non-surgical treatment regimens, and building clinical practice guidelines.

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Figure 1.
Flow diagram of the number of patients meeting inclusion and exclusion criteria.

Figure 2.

Flow diagram of recurrence and perforation in non-operatively managed uncomplicated appendicitis for patients admitted from 1997–2008 with follow-up through 2010.

TABLE 1
Characteristics of All Patients with Uncomplicated Appendicitis from 1997 to 2008 by Operative vs Non-Operative Cohorts

	No. of patients with complete data	All patients (n=231,678)	Surgical patients (n=228,308)	Non-operative (n=3,370)	p Value
Insurance status, n (%)	229,890				
Medicare/private	-	158,492 (68.9)	156,314 (69.0)	2,178 (65.0)	<0.001*
Medicaid and other state	-	54,672 (23.8)	53,745 (23.7)	927 (27.7)	
Uninsured	-	16,726 (7.3)	16,482 (7.3)	244 (7.3)	
Age, mean (SD), y	231,678	32.4 (17.0)	32.3 (16.9)	41.0 (21.4)	<0.001*
Race, n (%)	229,311				
White	-	118,179 (51.5)	116,571 (51.6)	1,608 (48.1)	<0.001*
Black	-	8,622 (3.8)	8,381 (3.7)	241 (7.2)	
Hispanic	-	77,273 (33.7)	76,209 (33.7)	1,064 (31.8)	
Asian or Pacific Islander	-	18,194 (7.9)	17,860 (7.9)	334 (10.0)	
Native American/Other	-	7,043 (3.1)	6,947 (3.1)	96 (2.9)	
Sex, female, n (%)	231,667	102,227 (44.1)	100,504 (44.0)	1,723 (51.1)	<0.001*
Comorbidity	231,678				
Charlson Index, mean (SD)	-	0.16 (0.6)	0.15 (0.6)	0.60 (1.4)	<0.001*
Charlson 3+, n (%)	-	3,698 (1.6)	3,387 (1.5)	311 (9.2)	<0.001*
Secondary outcomes					
In-hospital mortality, n (%)	231,678	192 (0.1)	141 (0.1)	51 (1.5)	<0.001*
Mortality attributed to disease of appendix, n (%) [†]	216,859	13 (0.01)	12 (0.01)	1 (0.03)	0.06
30 d all-cause mortality, n (%)	231,678	260 (0.1)	227 (0.1)	33 (1.0)	<0.001*
Mean length of stay (SD), days	231,678	2.1 (2.9)	2.1 (2.8)	4.4 (6.6)	<0.001*
Mean total charges (SD), \$1,000	231,678	23.3 (33.6)	23.2 (32.3)	36.2 (81.6)	<0.001*
Hospital setting, teaching, n (%)	231,678	20,672 (8.9)	20,249 (8.9)	423 (12.6)	<0.001*
Duration of follow-up, y, mean (SD)	231,678	7.4 (3.4)	7.4 (3.4)	7.3 (3.9)	0.0336*

* Significant.

[†] Cause of Death data only available after 1998, 248,388 eligible patients. This variable was not recorded within the OSHPD database prior to this time.

TABLE 2

Causes of Mortality in Non-Operative Patients after 1998

Cause of death categorization	n	%
Etiology attributed to appendicitis	1	2.5
Diseases of appendix	1	2.5
Etiology related to chronic condition	23	57.5
Vascular disorder and obstruction without hernia	6	15.0
Chronic ischemic heart disease	3	7.5
Chronic obstructive pulmonary disease	3	7.5
Aortic aneurysm and dissection	3	7.5
Diverticular disease of intestine	2	5.0
Cardiomyopathy	2	5.0
Stroke	2	5.0
Infantile cerebral palsy	1	2.5
Hypertensive renal disease and secondary hypertension	1	2.5
Etiology related to malignancy	6	15.0
Malignant neoplasm of colon	2	5.0
Non hodgkin lymphoma	2	5.0
Malignant neoplasm of esophagus	1	2.5
Malignant neoplasm of trachea, bronchus, and lung	1	2.5
Etiology related to acute or uncertain processes	10	25.0
Pneumonia due to other or unspecified organism	1	2.5
All other respiratory diseases	1	2.5
Hernia	1	2.5
Diseases of peritoneum	1	2.5
Other disease of liver	1	2.5
Cholelithiasis and other disorders of gallbladder	1	2.5
Renal failure	1	2.5
Urinary tract infection, site not specified	1	2.5
Obstruction of respiratory tract	1	2.5
Intentional self poisoning	1	2.5

There were 51 deaths in the non-operative cohort during this time. Of these, 40 had a recorded cause of death.

TABLE 3

Results from Multivariable Logistic Regression Models for Treatment Failure, Recurrence, and Perforation in Non-Operatively Managed Patients with Appendicitis from 1997 to 2008

	Treatment failure			Recurrence			Perforation		
	OR (95% CI)	p Value		OR (95% CI)	p Value		OR (95% CI)	p Value	
Insurance status									
Medicare and private	1 [Reference]			1 [Reference]			1 [Reference]		
Medicaid	1.00 (0.68–1.47)	0.99		1.09 (0.70–1.68)	0.71		1.03 (0.61–1.74)	0.90	
Uninsured	0.81 (0.42–1.56)	0.53		0.70 (0.32–1.51)	0.36		0.88 (0.36–2.15)	0.78	
Race									
White	1 [Reference]			1 [Reference]			1 [Reference]		
Black	1.09 (0.62–1.92)	0.76		1.14 (0.56–2.32)	0.71		1.28 (0.58–2.82)	0.54	
Hispanic	0.75 (0.52–1.09)	0.13		1.48 (0.97–2.24)	0.07		1.09 (0.66–1.80)	0.73	
Asian or Pacific Islander	0.52 (0.27–0.97)	0.041*		1.53 (0.88–2.64)	0.13		1.11 (0.56–2.20)	0.77	
Native American/other	0.85 (0.33–2.17)	0.74		–	–		–	–	
Sex									
Male	1 [Reference]			1 [Reference]			1 [Reference]		
Female	1.02 (0.75–1.37)	0.92		0.70 (0.50–0.99)	0.046*		0.83 (0.55–1.25)	0.37	
Charlson Index									
0	1 [Reference]			1 [Reference]			1 [Reference]		
1–2	1.06 (0.68–1.65)	0.80		0.83 (0.49–1.39)	0.48		1.44 (0.83–2.48)	0.19	
3+	0.61 (0.32–1.17)	0.14		0.62 (0.29–1.33)	0.22		0.42 (0.15–1.20)	0.11	
Age, y									
0–9	1 [Reference]			1 [Reference]			1 [Reference]		
10–19	0.59 (0.32–1.09)	0.09		3.34 (1.12–9.91)	0.030*		1.00 (0.44–2.32)	0.99	
20–29	0.52 (0.28–0.97)	0.038*		2.09 (0.68–6.36)	0.20		0.31 (0.12–0.85)	0.023*	
30–39	0.33 (0.17–0.63)	0.001*		2.27 (0.75–6.83)	0.15		0.47 (0.19–1.16)	0.10	
40–49	0.46 (0.26–0.87)	0.017*		3.21 (1.08–9.54)	0.036*		0.46 (0.18–1.16)	0.10	

	Treatment failure		Recurrence		Perforation	
	OR (95% CI)	p Value	OR (95% CI)	p Value	OR (95% CI)	p Value
50–59	0.30 (0.14–0.64)	0.002*	2.58 (0.81–8.18)	0.11	0.47 (0.17–1.28)	0.14
60–69	0.44 (0.20–0.95)	0.037*	4.31 (1.34–13.8)	0.014*	0.94 (0.35–2.50)	0.90
70–79	0.58 (0.27–1.25)	0.17	3.41 (0.98–11.9)	0.05	0.80 (0.28–2.34)	0.69
80–89	0.60 (0.24–1.52)	0.28	2.79 (0.64–12.1)	0.17	1.41 (0.45–4.41)	0.56
90+	1.49 (0.46–4.77)	0.50	7.03 (1.14–43.6)	0.036*	0.73 (0.08–6.57)	0.78
Hospital setting						
Non-teaching	1 [Reference]		1 [Reference]		1 [Reference]	
Teaching	1.07 (0.67–1.70)	0.78	2.15 (1.40–3.31)	<0.001*	2.28 (1.38–3.78)	0.001*

Though not displayed, year of admission was also included as a covariate. Odds ratio (OR) is defined as the odds that the outcome of interest will occur given a particular value of a variable of interest relative to the odds that the outcome will occur for a reference value of that variable. Pseudo R^2 for treatment failure, recurrence, and perforation models were 0.03, 0.05, and 0.06, respectively.

* Significant.