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Incidence, demographics, and outcomes of nonoperative management of appendicitis in the United States

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ARTICLE INFO

Article history:

Received 13 August 2017

Received in revised form

8 September 2017

Accepted 12 October 2017

Available online xxx

Keywords:

Nonoperative

Appendicitis

Antibiotics-first

ABSTRACT

Background: Appendicitis is the most common intraabdominal surgical emergency in the United States, with over 250,000 cases each year. Several recent studies have evaluated the efficacy of nonoperative management of appendicitis. We measured changes in the treatment of appendicitis in the United States from 1998 to 2014 and evaluated outcomes in the contemporary cohort of appendicitis cases from 2010 to 2014.

Methods: The National Inpatient Sample was queried for cases with a principal diagnosis of appendicitis. Cases with peritoneal abscesses were excluded. We determined trends in management and then compared cases managed nonoperatively versus those managed with early operation for demographics and outcomes including mortality, total charges, and length of stay using univariate analysis, binary logistic regression analysis, and case-control matching.

Results: Although early operation remains the dominate treatment for acute appendicitis in the United States, there is an accelerating trend in nonoperative management. Nonoperative management is associated with increased age, number of comorbidities, and inpatient diagnoses. In univariate, multiple regression, and case-control analysis, nonoperative management is associated with decreased total charges but significantly increased risk of mortality.

Conclusions: Elderly patients and patients with medical comorbidities are more likely to be treated nonoperatively for appendicitis than younger patients. Although previously published data support nonoperative management of appendicitis in low-risk surgical patients, we suggest that elderly or medically complex patients may benefit from early operative treatment of appendicitis and are potentially at risk of poor outcomes from nonoperative management.

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Introduction

Acute appendicitis remains one of the most common general surgical emergencies in the United States with an incidence of 9.4–11 per 10,000 person-years.^{1,2} For over 100 y, appendicitis

has been recognized as a condition requiring surgical treatment. In 1886, speaking at the inaugural meeting of the American Association of Physicians, Reginald Fitz coined the term “appendicitis” and proposed that appendicitis invariably progresses from luminal obstruction to necrosis, perforation,

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<https://doi.org/10.1016/j.jss.2017.10.007>

appendiceal abscess formation, peritonitis, and eventual death.³ As such, Dr Fitz advocated urgent laparotomy for all cases of suspected appendicitis.³ By the 50th anniversary of the American Association of Physicians meeting in 1935, “almost universally appendicitis had come to be regarded as a surgical ailment” with operative mortality for acute appendicitis already as low as 0.7%.⁴

Recent data challenge the surgical dogma that appendicitis is always due to luminal obstruction and therefore requires emergent appendectomy,⁵ and there have been several randomized controlled trials evaluating an antibiotics-first nonoperative treatment strategy for acute uncomplicated appendicitis.⁶⁻¹¹ A recent meta-analysis found that antibiotic treatment resulted in resolution of uncomplicated appendicitis in 91% of cases, though 17.8% had recurrence requiring surgical treatment within a year.¹² At present, the American College of Surgeons,¹³ Society for Surgery of the Alimentary Tract,¹⁴ European Association for Endoscopic Surgery,¹⁵ and the World Society of Emergency Surgery¹⁶ continue to recommend laparoscopic or open appendectomy as the first-line therapy for adults with acute uncomplicated appendicitis, although all of these organizations recognize a role for an antibiotics-first nonoperative approach in selected patients.

Although several randomized controlled trials have evaluated outcomes of operative *versus* nonoperative management of appendicitis, there are limited data on the practice pattern and outcomes of appendicitis treatment in the United States. Given the developing literature supporting nonoperative management of appendicitis, we sought to define the incidence and outcomes of operative *versus* nonoperative management of appendicitis in the United States using the National/Nationwide Inpatient Sample (NIS), an federally administered database which collects data on approximately 20% of the US hospital discharges, including demographics; diagnoses; and administrative outcomes such as length of stay (LOS), hospital charges, and mortality. We found that since 2010, there has been a significant increase in the rate of nonoperative management of appendicitis in the United States. We report that elderly patients and patients with comorbidities are more likely to be managed nonoperatively. We further report an association between nonoperative management and mortality, and we are concerned that this indicates that nonoperative management of elderly patients with comorbidities having appendicitis may be associated with an increased risk for morbidity not captured in the NIS.

Methods

The 1998-2014 NIS were queried for cases with a principal diagnosis of appendicitis (Clinical Classification Software code 142) and age ≥ 18 y. Cases with associated peritoneal abscesses (International Classification of Diseases [ICD]-9 code: 540.1), elective admissions, missing procedural data, and inter-hospital transfer were excluded. The Elixhauser comorbidity indices were calculated via publically available software, and the van Walraven index was calculated.¹⁷⁻¹⁹ The Elixhauser index is a retrospectively derived comorbidity index used with administrative data. It consists of 30 comorbidity measures and was specifically derived for use in controlling for

preexisting conditions.¹⁸ Since first described in 1997, the Elixhauser index has been extensively validated in numerous populations.²⁰ For the purpose of simplifying the index into a single score, the van Walraven modification was applied as previously described.¹⁷

Cases were defined as having early surgical management if they underwent appendectomy or a colorectal procedure (colostomy, colorectal resection, local excision of large intestine lesion) on hospital day 1 or 2 based on the presence of one or more procedure ICD-9 codes (see [Supplemental Table A](#)). Cases that underwent colorectal operations other than appendectomy were included to decrease the chance of selecting less complicated patients into the early operative group and biasing these results. Percutaneous drainage was identified based on procedure ICD-9 code 549.1. Cases undergoing operation after hospital day 2 were classified as delayed surgical management. We also defined cohorts that underwent surgical management with later percutaneous drainage or early percutaneous drainage with delayed operative management. Nonoperative management was defined as cases in which there was no surgical operation or percutaneous drainage procedure during the hospital visit. Overall trends in each intervention were evaluated using the Cochran–Armitage test.

The contemporary subset of cases in the NIS from 2010 to 2014 was then analyzed. Chi-square tests were used to determine associations between categorical variables. Continuous variables were compared using Student’s *t*-test. Binomial logistic regression analysis was used to identify risk factors for mortality from appendicitis. We specifically chose principal diagnosis, age, sex, Elixhauser comorbidity score with van Walraven modification, number of inpatient diagnoses, and race as these were the only patient variables available in the NIS. We report the adjusted odds ratios (ORs) and 95% confidence intervals as well as goodness-of-fit measures and area under the curve for the associated receiver operating curve.

Cases managed nonoperatively were then matched to cases managed with early operation for risk factors independently associated with mortality in the logistic regression analysis. Nonoperatively managed cases were matched to cases undergoing early operative management for age within 5 y, Elixhauser comorbidity score with van Walraven modification within five points, exact number of inpatient diagnoses, African-American race, and ICD-9 diagnosis code 540.9. Case matching was performed using SPSS, version 23.0 (2015; IBM Corp, Armonk, NY). Mortality was analyzed by chi-squared test and LOS and total charges by Student’s *t*-test.

Results

Trends in management of acute appendicitis, 1998-2014

From 1998 to 2014, there were 477,680 cases that met inclusion criteria. Of all, 453,739 were managed with early operation, 9369 underwent delayed operative management, and 12,100 were managed nonoperatively. The remainder received a drainage procedure with or without surgery. Over the study period, the proportion of cases managed with early operation decreased from 94.6% to 92.1%, ($P < 0.001$, Cochran–Armitage

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