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Population-level outcomes of early *versus* delayed appendectomy for acute appendicitis using the American College of Surgeons National Surgical Quality Improvement Program

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ABSTRACT

Background: The optimal timing of appendectomy for acute appendicitis has been analyzed with mixed results. We hypothesized that delayed appendectomy would be associated with increased 30-d morbidity and mortality.

Materials and methods: The American College of Surgeons National Surgical Quality Improvement Program database was queried for all patients undergoing nonelective appendectomy from 2012 to 2015 with a postoperative diagnosis of appendicitis. Patients were grouped based on hospital day (HD) of operation. Primary outcomes included 30-d mortality and major complications. Logistic regression was performed to determine predictors of major morbidity and mortality.

Results: From 2012 to 2015, 112,122 patients underwent appendectomy for acute appendicitis. Appendectomies performed on HD 3 had significantly worse outcomes as demonstrated by increased 30-d mortality (0.6%) and all major postoperative complications (8%) in comparison with operations taking place on HD 1 (0.1%; 3.4%) or HD 2 (0.1%, $P < 0.001$; 3.6%, $P < 0.001$). In subgroup analysis, open operations had significantly higher mortality and major postoperative complications, including organ/space surgical site infections (4.6% open *versus* 2.1% laparoscopic; $P < 0.001$). Patients with decreased baseline physical status by the American Society of Anesthesiologists Physical Status class had the worst outcomes (1.5% mortality; 14% major complications) when operation was delayed to HD 3. Logistic regression revealed higher American Society of Anesthesiologists Physical Status class and open operations as predictors of major complications; however, HD was not ($P = 0.2$).

Conclusions: Data from the American College of Surgeons National Surgical Quality Improvement Program demonstrate similar outcomes of appendectomy for acute appendicitis when the operation is performed on HD 1 or 2; however, outcomes are significantly worse for

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appendectomies delayed until HD 3. Increased complications in this group are likely not attributable to HD of operation, but rather decreased baseline health status and procedure type.

Introduction

Approximately 245,000 people undergo operations for acute appendicitis in the United States each year, making appendectomy one of the most common abdominal surgeries performed.[1,2] The underlying progression of appendicitis is thought to be time dependent, advancing from simple appendicitis to perforation, and in some cases, generalized peritonitis.[3] Dr. Reginald H. Fitz, the first to use the term "appendicitis" in 1886, was also the first to advocate for early surgical intervention.[4,5] As Dr. Fitz once wrote in reference to acute appendicitis, "the speedy death of the patient almost invariably results from occurrence of the general peritonitis."[4] It is this risk of perforation that has established early operative intervention for acute appendicitis as common surgical doctrine, a teaching which has remained relatively unchanged since it was first described.

More recently, there have been questions regarding the ideal timing of appendectomy. Some advocate that a delay in operation is safe, whereas others report worsened outcomes with a delay as short as 6 h from initial presentation.[6-8] With an evolution in health-care delivery of resources and personnel as well as an emphasis on quality of care in the present-day health-care setting, discerning a safe delay in appendectomy has the potential to help optimize both resource and operating room utilization. In addition, with increasing patient complexity marked by increased prevalence of obesity and comorbid conditions, a question arises whether delay in operation in favor of medical optimization or earlier surgical intervention is preferable.[9]

First, we aim to examine these questions using the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database to evaluate 30-d outcomes of early *versus* delayed appendectomy. Second, we aim to explore the effects of procedure type (open *versus* laparoscopic) and baseline physical status as determined by the American Society of Anesthesiologists Physical Status (ASA-PS) classification on the effects of delayed surgical intervention. We hypothesized that a prolonged delay in operative intervention would lead to increased patient morbidity and mortality.

Materials and methods

Data acquisition

All data were acquired from the ACS-NSQIP participant user files, which provide data from participating hospitals across the United States.[10] Patient data are collected on an 8-d sampling cycle to guarantee random sampling of cases from each institution. All participating hospitals must maintain an 80% or greater 30-d follow-up rate to ensure quality of the data gathered. The database has continued to expand each year, comprising 183 participating hospitals in 2007 to 603 hospitals in 2015. Because the ACS-NSQIP database contains de-identified patient information, this study was not considered human subjects research and was therefore exempt from the Institutional Review Board approval.

The ACS-NSQIP database was queried for all patients undergoing appendectomy from 2007 to 2015 based on Current Procedural Terminology codes, including 44950 (open appendectomy), 44960 (open appendectomy for ruptured appendix with abscess or generalized peritonitis), 44970 (laparoscopic appendectomy), and 44979 (laparoscopic procedure on appendix). Only patients with a postoperative diagnosis of appendicitis by the International Classification of Disease (ICD) code were included in the analysis. The following codes were used: ICD-9 codes 540 (acute appendicitis), 540.0 (acute appendicitis with generalized peritonitis), 540.1 (acute appendicitis with peritoneal abscess), 540.9 (acute appendicitis without peritonitis), 541 (appendicitis unqualified), 542 (other appendicitis), and ICD-10 codes K35 (acute appendicitis), K35.2 (acute appendicitis with generalized peritonitis), K35.3 (acute appendicitis with localized peritonitis), K35.8 (other and unspecified acute appendicitis), K35.80 (unspecified acute appendicitis), K35.89 (other acute appendicitis), K36 (other appendicitis), and K37 (unspecified appendicitis). Patients were excluded if hospital day (HD) of operation was greater than or equal to 4 d from hospital admission in an attempt to exclude patients with missed diagnosis as a cause of delay in operation as well as exclude those who may have failed an initial trial of antibiotic management. The resulting cohort was utilized to access for a trend in the percentage of patients undergoing appendectomy on the first day of hospital admission each year.

For further analysis of 30-d outcomes, the cohort was restricted to only patients undergoing nonelective appendectomy during 2012-2015 to utilize valuable variables that were established in the database that year. Patients were then grouped by HD 1, 2, or 3 based on the number of days from hospital admission to operation.

Baseline characteristics

The following were considered as possible risk factors for postoperative morbidity and mortality: patient factors including demographics (age, sex, race, and body mass index), functional status, ASA-PS class, procedure type (laparoscopic *versus* open), transfer status from outside hospital or emergency department, comorbid conditions (current smoker, hypertension, diabetes, bleeding disorders, chronic steroid use, chronic obstructive pulmonary disease, dyspnea, dialysis, disseminated cancer, open wound, unintentional weight loss of >10% body weight in the previous 6 mo, congestive heart failure, and ascites), and clinical risk factors (white blood cell count, sepsis at time of presentation, red blood cell [RBC] transfusion preoperatively,