The American Journal of Surgery (2016) 212, 1076-1082

The American Journal of Surgery®

Southwestern Surgical Congress

Misdiagnosing adult appendicitis: clinical, cost, and socioeconomic implications of negative appendectomy

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KEYWORDS:
Appendicitis;
Negative appendectomy;
Hospital cost;
Health care disparity

Abstract

BACKGROUND: The aim of this study was to evaluate the clinical, financial, and socioeconomic factors associated with negative appendectomy (NA).

METHODS: Data were obtained from the California State Inpatient Database (2005 to 2011). Patients (≥18 years) who underwent nonincidental appendectomies (n = 180,958) were evaluated with multivariate regression analyses.

RESULTS: NA rates decreased from 4.5% in 2005 to 2.8% in 2011 ($P < .01$). Compared with patients with nonperforated appendicitis, NA was associated with longer length of stay, higher morbidity, and higher hospital costs. Multivariate regression demonstrated that African Americans, younger age (18 to 29 years), and females were predictors of NA. Hispanics and patients with public or no insurance were associated with a lower NA rate; however, perforation rates were higher.

CONCLUSIONS: NA was associated with higher cost, longer length of stay, and higher morbidity compared with nonperforated appendicitis. Lower NA rates but higher perforation rates in some populations suggest a delay in presentation. Further research is needed to understand these disparities and to improve quality of care among low-income minority patients.

Traditionally, it has been believed that the early diagnosis of appendicitis is critical in preventing progression of disease and possible appendiceal perforation.[1] Many argue that negative appendectomy (NA) is justified to decrease the risk of perforated appendicitis as it has been accepted that an inverse relationship exists between the rates of NA and perforated appendicitis.[2] However, with the increasing prevalence of preoperative imaging, the rate of NA has been decreasing, whereas the rate of perforated appendicitis has remained largely unchanged implying that there may not in fact be an inverse relationship between the 2.[3–6] Thus, the exact relationship between the rates of NA and perforated appendicitis remains unclear. NA was also justified as it is believed to be associated

There were no relevant financial relationships or any sources of support in the form of grants, equipment, or drugs.

The authors declare no conflicts of interest.

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Manuscript received March 19, 2016; revised manuscript September 2, 2016

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http://dx.doi.org/10.1016/j.amjsurg.2016.09.005

with minimal morbidity and cost. However, the clinical and economic burden associated with NA has not been recently studied. Thus, the purpose of this study was to determine the clinical and socioeconomic implications of NA using data on inpatient admissions and hospital characteristics in the state of California. We also sought to further investigate the relationship between the rates of NA and perforated appendicitis.

Methods

We used the California State Inpatient Databases (SID) from the Healthcare Cost and Utilization Project, which include all inpatient discharges from nongovernmental hospitals in the state of California. The SID provides discharge data, such as patient demographics, insurance status, discharge diagnoses, procedures performed, length of stay (LOS), and total charges. Cost was derived and inflation adjusted to 2010 dollars using the cost-to-charge ratio files provided by Healthcare Cost and Utilization Project and published medical consumer price index. Hospital characteristics, such as teaching hospital status and ownership type (public or private), were obtained from the California Hospital Annual Utilization data.

The study sample consisted of adult (age $\geq$18 years) inpatient admissions for which a nonincidental appendectomy was the primary procedure. Cases were identified by searching SID for the years of 2005 to 2011 for all discharges with the *International Classification of Diseases, Ninth Revision* (*ICD-9*) codes of 47.0 (appendectomy), 47.01 (laparoscopic appendectomy), and 47.09 (other appendectomy) listed as the primary procedure.[7,8] Patients older than 70 years were excluded from the study because of age-related confounders that might also affect comorbidity rates and cost.

We categorized appendectomy admissions into 3 broad types: NA, nonperforated appendicitis, and perforated appendicitis. NA was defined as a nonincidental appendectomy without a diagnosis of appendicitis.[7] Appendectomies where a diagnosis of appendicitis was not among the first 3 diagnoses were also considered negative, given the possibility that suspected appendicitis on presentation is coded as a nonprimary appendicitis diagnosis even without eventual confirmation of the diagnosis of appendicitis.

Appendectomy with nonperforated appendicitis was identified with one or more of the following *ICD-9* diagnosis codes: 540.9 (acute appendicitis without mention of peritonitis), 541 (appendicitis, unqualified), and 542 (other appendicitis). Appendectomy with perforated appendicitis was identified by either *ICD-9* diagnosis code 540.0 (acute appendicitis with generalized peritonitis) or 540.1 (acute appendicitis with peritoneal abscess).[7,8]

Complications commonly associated with appendectomy were also investigated, including intra-abdominal abscess, wound infection, cardiac, respiratory, and renal complications and intestinal obstruction.[9]

Covariates included in the study were age, gender, race or ethnicity, insurance type, type of appendectomy (open vs. laparoscopic), hospital ownership (public or private), hospital status (teaching vs. nonteaching), quartiles of hospital volume (number of appendectomies performed per year), and calendar year.

Analyses were performed at both the patient and hospital-year levels. At the patient level, we examined predictors of NA and its implications on cost, LOS, and comorbidity compared with appendectomies with nonperforated and perforated appendicitis. Multivariate logistic regression was performed on the outcomes of NA and comorbidity. Multiple median regression was performed on the outcome of cost with clustered standard errors.[10] Negative binomial regression was performed on the outcome of LOS. All patient-level analyses were clustered by the hospital's respective Federal Information Processing Standard county code.

At the hospital-year level, 2 separate hierarchical multivariate linear regressions were performed to assess factors associated with the outcome of NA and with the outcome of appendectomy with perforated appendicitis. Because of right-skewed distributions, both outcomes were logarithmically transformed in the regression. The hierarchical models included hospital and Federal Information Processing Standard county code-level analyses.

Results

During the study period, 180,958 appendectomy admissions were identified (Table 1). The prevalence of NA decreased from 4.5% to 2.8% in California from 2005 to 2011. The prevalence of perforated appendicitis only decreased from 23.1% to 21.7%. The total cost of NA decreased from $11 to $9 million per year, whereas the total cost of perforated appendicitis increased from $70 to $72 million per year (Fig. 1). Compared with patients with nonperforated appendicitis, NA was associated with longer LOS and higher morbidity (Fig. 1).

Results of the multivariate analysis are summarized in Table 2. Multivariate analysis showed that NA was more likely to be associated with female gender (odds ratio [OR] = 2.50, $P < .01$), African American race (OR = 1.61, $P < .01$), and public insurance (OR = 1.39, $P < .01$). Conversely, Hispanic patients (OR = .71, $P < .01$), hospitals in the highest quartile of appendectomy volume ($\geq$181 per year) (OR = .88, $P < .03$), and teaching hospitals (OR = .81, $P = .04$) were associated with lower NA rates. NA have a median cost of approximately $1,063 more per admission ($P < .01$), incurred an additional .8 days in LOS ($P < .01$), and was associated with higher morbidity (OR = 2.45, $P < .01$) than appendectomy for nonperforated appendicitis.

Multivariate analyses at the hospital-year level found that NA rates did not correlate with the appendiceal perforation rates. Similar to patient-level analyses, NA