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Association for Academic Surgery

Regional variations in outcomes and cost of appendectomy in the United States

Roy P. Won, MD,[a,c] Scott Friedlander, MPH,[b,c] and Steven L. Lee, MD[a,b,c,*]

[a] Department of Surgery, Harbor-UCLA Medical Center, Torrance, California
[b] Department of Pediatrics, Harbor-UCLA Medical Center, Torrance, California
[c] Los Angeles Biomedical Research Institute, Torrance, California

ARTICLE INFO

Article history:
Received 9 February 2017
Received in revised form
31 May 2017
Accepted 16 June 2017

Keywords:
Adult appendicitis
Regional variations
Outcomes
Costs

ABSTRACT

Background: The study of regional variations in surgical outcomes and cost has been used to identify areas for improvement and savings. This study investigates potential regional differences in the outcomes and cost of adult appendicitis. We hypothesized that there would be no difference in rates of laparoscopy, perforation, morbidity, length of stay (LOS), and cost among different regions of the United States.

Materials and methods: Data were obtained from the California (CA), New York (NY), and Florida (FL) State Inpatient Databases from 2005-2011. Patients between the ages of 18-69 who underwent nonincidental appendectomy in the three different states were evaluated with hierarchical and multivariate negative binomial regression analyses. Primary outcomes included laparoscopy, perforation, negative appendectomy, morbidity, LOS, and cost.

Results: There were 371,354 appendectomies performed. Multivariate analysis revealed multiple regional differences. Patients in FL were most likely to get laparoscopy ($P < 0.01$). CA had higher rates of perforation than NY ($P < 0.01$) and FL ($P < 0.05$). CA also had higher rates of negative appendectomy compared to both NY and FL ($P < 0.01$). Morbidity was lower in NY compared to CA and FL ($P < 0.01$). The LOS was shortest in CA ($P < 0.01$), despite CA having the highest median per patient cost ($P < 0.01$).

Conclusions: Significant regional variations do exist with CA having the highest rate of perforation and negative appendectomy. Patients in CA also incurred the highest overall costs. A better understanding of the factors that drive these variations will help improve outcomes and lower cost across all states.

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Introduction

Appendectomy for acute appendicitis is the most common urgent, intra-abdominal surgery performed in the United States. Despite being so common, diagnosis can be difficult given up to 40% present with atypical symptoms.[1] Preoperative imaging can be highly sensitive and specific, but add cost, exposure to ionizing radiation, and time.[2] The added time may delay the treatment and increase the risk for perforation.[3] Forgoing imaging increases risk for

* *Corresponding author*. Department of Surgery, Harbor UCLA Medical Center, 1000 W Carson Street, Box 461, Torrance, CA 90502, Tel.: +310 222-2700; fax: +310 533-1841.
E-mail address: slleemd@yahoo.com (S.L. Lee).
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http://dx.doi.org/10.1016/j.jss.2017.06.051

misdiagnosis and negative appendectomy subjecting the patient to an unnecessary surgery.[4] Perforated appendicitis and negative appendectomy are the two negative outcomes that have been decreasing over the last 2 decades with increasing use of preoperative imaging.[5,6] However, they are still followed as quality indicators for the management of appendicitis. Both have been linked to social factors including age, sex, race, income, and insurance status.[7,8] Rates of perforation and negative appendectomy have been shown to be increased in minorities and the uninsured, while patients from rural areas have been shown to have higher rates of perforation.[8,9]

One of the overarching goals of Healthy People 2020 by the Department of Health and Human Services is to "achieve health equity, eliminate disparities, and improve the health of all groups." With respect to appendicitis, numerous studies have examined the effects of race and socioeconomic status on these disparities, yet few have looked at the geographic variations across the United States. Therefore, it was our aim to compare the outcomes and costs across regions by comparing three different states. Our hypothesis was that there would be no difference in rates of laparoscopy, perforation, morbidity, length of stay (LOS), and cost.

Materials and methods

Data source

We used the California (CA), New York (NY), and Florida (FL) State Inpatient Databases (SIDs) from the Healthcare Cost and Utilization Project, which includes all inpatient discharges from nongovernmental hospitals in each state. It contains discharge data such as patient demographics, insurance status, discharge diagnoses, procedures performed, LOS, and total charges. Cost was inflation adjusted to 2010 dollars using the cost-to-charge ratio files provided by the Healthcare Cost and Utilization Project and published medical consumer price index. To adjust for market conditions in different regions, total costs were then multiplied by the average wage index, which accounts for variations in wage rates. The Hospital Annual Utilization Data was used to determine hospital characteristics, such as teaching hospital status, annual appendectomy volume, and ownership type (public or private).[6,10]

Study population

We queried the CA, NY, and FL SIDs from 2005-2011 for all inpatient nonincidental appendectomies listed as the primary procedure in adults aged 18-69 y. We used International Classification of Diseases, Ninth Revision (ICD-9) codes 47.0 (appendectomy), 47.01 (laparoscopic appendectomy), and 47.09 (other appendectomy). We excluded patients aged 70 y and older due to concerns that age-related confounders may affect cost and outcomes.[6,10] Every nonincidental appendectomy was then separated into one of three cohorts based on the state in which it was performed, CA, NY, or FL.

Outcomes

Primary outcomes included diagnosis or type of nonincidental appendectomy, use of laparoscopy, complications, LOS, and cost. Every nonincidental appendectomy was categorized into one of three types: appendectomy for acute, nonperforated appendicitis; appendectomy for perforated appendicitis; and appendectomy without a diagnosis of appendicitis or negative appendectomy. Appendectomy for acute, nonperforated appendicitis was identified with ICD-9 codes 540.9 (acute appendicitis without mention of peritonitis), 541 (appendicitis, unqualified), and 542 (other appendicitis). Appendectomy for perforated appendicitis was identified by ICD-9 codes 540.0 (acute appendicitis with generalized peritonitis) or 540.1 (acute appendicitis with peritoneal abscess). A negative appendectomy was defined as a nonincidental appendectomy without a diagnosis of appendicitis. Appendectomies in which a diagnosis of appendicitis was not among the first three diagnoses were also considered negative given the possibility that suspected appendicitis at presentation was coded as a nonprimary appendicitis even when the appendix was found to be normal during the operation.[6,10] We investigated common complications associated with appendectomy including infectious complications, intestinal complications, and other miscellaneous complications using appropriate ICD-9 codes. Miscellaneous complications included renal failure, postoperative respiratory complications (i.e., atelectasis, pneumonia, pneumothorax, and acute respiratory insufficiency), and postoperative cardiovascular complications (i.e., deep vein thrombosis, pulmonary embolus, postoperative stroke, and cardiac arrest).

Statistical analysis

Bivariate and multivariate analyses were performed at the patient level with primary outcomes including diagnosis or type of appendectomy, complications, use of laparoscopy, LOS, and cost. Our multivariate analysis of perforated appendicitis and negative appendectomy was performed with a multinomial logistic regression allowing us to compare results of perforated appendicitis and negative appendectomy exclusively to nonperforated appendectomies. Negative binomial regression was performed on LOS, and multiple median regression was performed on cost. All multivariate analyses were clustered by each hospital's respective Federal Information Processing Standard county code. Covariates included in each multivariable regression analyses were age, gender, race/ethnicity, insurance type, hospital ownership (public or private), teaching hospital status, and hospital volume (number of appendectomy performed per year).[6,10] We also examined trends in the proportion of appendectomies that were performed for acute, nonperforated appendicitis; perforated appendicitis; and negative appendectomy. To determine how these trends differed by state, we compared the three states using a logistic regression for each diagnosis or appendectomy type predicted by an interaction of state and year. All data analyses were conducted using Stata 14.1 software.

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