
Comparative Analysis of Perioperative Outcomes and Costs Between Laparoscopic and Open Antireflux Surgery



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- BACKGROUND:** Laparoscopic antireflux surgery (LARS) has proven to be as effective as open antireflux surgery (OARS), but it is associated with a shorter hospital stay and a faster recover. The aims of this study were to assess the national use of LARS in the US and to compare the perioperative outcomes between laparoscopic and open antireflux procedures in a national cohort.
- STUDY DESIGN:** A retrospective population-based analysis was performed using the National Inpatient Sample for the period 2000 to 2013. The study included adult patients (18 years and older) diagnosed with gastroesophageal reflux disease (GERD), who underwent either laparoscopic or open fundoplication. Multivariable linear and logistic regression, adjusted for patient demographics, comorbidities, and hospital characteristics were used to assess the effect of the laparoscopic approach on patient outcomes.
- RESULTS:** A total of 75,544 patients were included, with 44,089 having LARS (58.4%) and 31,455 having OARS (41.6%). The rate of laparoscopic procedures increased from 24.8 LARS per 100 procedures in 2000, to 84.3 LARS per 100 procedures in 2013 ($p < 0.0001$). Patients undergoing laparoscopic surgery were less likely to experience postoperative venous thromboembolism, wound complications, infection, esophageal perforation, bleeding, cardiac failure, renal failure, respiratory failure, shock, and inpatient mortality. On average, the laparoscopic approach reduced length of stay by 2.1 days, and decreased hospital charges by \$9,530.
- CONCLUSIONS:** The use of the laparoscopic approach for the surgical treatment of GERD has increased significantly in the last decade in the US. This approach is associated with lower morbidity and mortality, shorter hospital stay, and lower costs for the health care system. (J Am Coll Surg 2017;224:327–333. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)
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Gastroesophageal reflux disease (GERD) affects approximately 20% of the population in the US, and its prevalence is increasing worldwide.¹ Lifestyle modifications and proton pump inhibitor therapy are effective in the majority of patients and remain the mainstay of GERD treatment. However, some patients will need surgical

intervention because they have only partial control of symptoms, do not want to be on long-term medical treatment, or suffer complications related to proton pump inhibitor therapy. The most commonly performed antireflux operation is the Nissen fundoplication (360 degrees), which has long-term success in about 80% to 90% of patients.^{2–4}

Laparoscopic antireflux surgery (LARS) was first reported in 1991^{5,6} and has since become widely accepted because of the clear advantages of a minimally invasive approach (decreased pain, shorter hospital stay, faster recovery, and almost complete absence of incisional hernia), and because it is as effective as open antireflux surgery (OARS).^{7–9} Interestingly, although the prevalence of GERD is increasing, and antireflux surgery has proven to be beneficial for patients, the use of antireflux procedures has declined in the US in recent years.^{10,11} Although the obesity epidemic and

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Abbreviations and Acronyms

GERD = gastroesophageal reflux disease
 LARS = laparoscopic antireflux surgery
 NIS = National Inpatient Sample
 OARS = open antireflux surgery
 OR = odds ratio

the rapid increase in the use of bariatric procedures may have contributed to this decline, patients' and gastroenterologists' concerns about surgical outcomes may also be related to the decrease in the number of antireflux operations.

We hypothesized that in the last decade, LARS was not universally embraced in the US, and that many operations were still performed through a laparotomy, with inferior perioperative outcomes. Therefore, the aims of this study were to assess the national use of LARS in the US, and to compare the perioperative outcomes between laparoscopic and open antireflux procedures in a national cohort.

METHODS

A cohort of patients was identified using the National Inpatient Sample (NIS) database between January 1, 2000 and December 31, 2013. The NIS is the largest publicly available, all-payer health care database in the US, and it includes more than 7 million hospitalizations from 1,000 hospitals each year, representing a 20% stratified sample of all hospital discharges in the US. Eligible patients were identified using International Classification of Disease, 9th revision, Clinical Modification (ICD-9-CM) diagnostic and procedural codes.

Adult patients (18 years or older) diagnosed with gastroesophageal reflux disease (530.11, 530.81, and 530.85), who underwent either an open (44.66) or laparoscopic (44.67) fundoplication during their inpatient hospitalization were eligible for inclusion. Comorbidities of interest included hypertension (401 to 401.9 and 402 to 402.91), primary and secondary diabetes (249 to 249.91 and 250 to 250.93), obesity (278 to 278.8), renal insufficiency (585 to 585.9), coronary artery disease (414 to 414.9), peripheral vascular disease (443 to 443.9), COPD (491 to 492.8), and sleep apnea (327.23).

Surgical outcomes of interest were inpatient mortality, postoperative complications during index hospitalization, length of stay, and total charges (excluding operating room time costs). Postoperative complications included venous thromboembolism (415.11, 453.40 to 453.42, and V12.51), wound complications (998.13, 998.30 to 998.32, and 998.83), infection (54.91, 86.04, 567.22, 569.5, 995.9 to 995.99, 996.64, 998.5 to 998.59, and 999.3 to 999.39), esophageal perforation (42.82 and

530.4), bleeding (99.0 to 99.09, 998.11, and 998.12), shock (998.0 to 998.09), cardiac failure (410 to 410.9, 428 to 428.9), renal failure (38.95, 39.95, 584 to 584.9, 586, and V45.11), and respiratory failure (31.1 to 31.29, 96.04, 96.05, 96.7 to 96.72, and 799.1). A composite complication (ie at least 1 postoperative complication) was also analyzed.

Statistical analyses

Patient demographics, hospital characteristics, and procedure type were compared across surgery type (laparoscopic vs open) using descriptive statistics. Unadjusted, bivariate analyses of mortality, length of stay, hospital charges, and complication incidence across surgical approach were also assessed using chi-square and Wilcoxon-Mann-Whitney tests. The yearly incidence of laparoscopic fundoplication was estimated using Poisson regression and was expressed as the number of laparoscopic procedures per 100 patients undergoing fundoplication.

Missing data for sex ($n = 228$; 0.3%), race/ethnicity ($n = 17,714$; 23.5%), primary insurance ($n = 321$; 0.4%), household income ($n = 1,696$; 2.3%), admission type ($n = 17,181$; 22.7%), hospital teaching status ($n = 330$; 0.4%), bed size ($n = 330$; 0.4%), inpatient mortality ($n = 26$; 0.0%), length of stay ($n = 2$; 0.0%), and hospital charges ($n = 1,374$; 1.8%) were estimated using Markov Chain Monte Carlo multiple imputation ($n = 40$). A noninformative prior, 200 burn-in iterations and 100 iterations between imputations was specified. The Markov Chain Monte Carlo models included the variables with missing data plus laparoscopic procedure, other postoperative complications, admission year, admission type, age, comorbidities, hospital region, and hospital surgical volume. Hospital surgical volume was categorized as <10 operations a year (low volume), 10 to 25 operations a year (intermediate volume), and >25 operations a year (high volume). Variables estimates were not rounded or bounded.

Main effect multivariable analyses on the potential effect on patient outcomes of laparoscopic surgery, compared with open procedures, were performed using linear and logistic regression, where appropriate, on the imputed datasets. Models were adjusted for admit year, age, sex, race/ethnicity, comorbidities, primary insurance, household income, admit type, hospital region, surgical volume, teaching status, and size. Patient age was modeled as linear variable, as determined by functional form assessment, and centered at 50 years old.

A value of $p < 0.05$ was considered significant for all the statistical methods. All analyses were performed using SAS software version 9.4 (SAS Inc).

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