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Laparoscopic Appendectomy in Children with Complicated Appendicitis: Ethnic Disparity Amid Changing Trend

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Background. **Laparoscopic appendectomy (LA) has gained acceptance in the treatment of uncomplicated appendicitis in the pediatric population. The role of LA *versus* open appendectomy (OA) in complicated (perforated) appendicitis has remained controversial.**

Methods. **A 10-y review of the Nationwide Inpatient Sample (HCUP-NIS) and 3 y of non-overlapping data from the Kids' Inpatient Database (KID) (2000, 2003, and 2006) was performed on pediatric patients (age <18 y) with complicated appendicitis. Patients were classified based on gender, race, insurance status, and type of appendectomy performed. Multivariate regression was conducted adjusting for age, race, gender, and type of appendectomy, with mortality and length of hospital stay (LOS) as outcomes.**

Results. **An estimated 72,787 patients met the inclusion criteria with a median age of 11 y. The majorities of the patients were male (59.9%), Caucasian (38.1%), and insured (89.7%). Twenty-nine percent underwent LA while 71% had OA. Proportion of LA increased from 9.9% in 1999 to 46.6% in 2007. On multivariate analysis, African-Americans were less likely to undergo LA compared with Caucasians (OR: 0.80, CI = 0.69–0.92, $P = 0.002$) despite an increased odds of undergoing LA over the last decade from 1998 to 2007 in the entire study population (OR 6.27, 95% CI 4.73–8.30, $P = 0.000$). Increasing age and gender were also associated with likelihood of receiving LA (OR: 1.08, CI = 1.06–1.10 and OR 1.25, 95% CI 1.18–1.31, $P < 0.001$).**

Conclusions. **LA is gradually gaining acceptance over the years as an alternative to OA for complicated appendicitis, However, minority difference still exists in choice of procedure. There is a need to further investigate this disparity as it may be related to access to skilled laparoscopic pediatric surgeons.**

Key Words: **laparoscopic appendectomy; open appendectomy; complicated appendicitis; ruptured appendicitis; perforated appendicitis.**

INTRODUCTION

Minimally invasive surgical (MIS) techniques are currently being employed across a variety of surgical specialties. With increasing laparoscopic experience, improvements in surgical technique and advances in technology have allowed for superior outcomes in minimally invasive surgery (MIS) compared with open procedures. As a result, laparoscopic procedures trend toward becoming the treatment of choice for select surgical conditions in adults.

In the pediatric population, appendectomy remains one of the most commonly performed surgical procedures. From a very skeptical beginning, LA has gained acceptance as the treatment of choice in the management of uncomplicated appendicitis in the pediatric and adult population [1–6]. This led to a significant increase in the rate of LA from 18.6% in 1999 to 52.4% in 2006 [7]. Its role in the management of complicated appendicitis in children remains somewhat controversial.

As the learning curve became less steep and more surgeons became familiar with minimally invasive techniques, surgeons started to explore the possibility of performing appendectomies laparoscopically even in complicated appendicitis. Initial results were very

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controversial, with concerns about intra-abdominal abscess (IAA) with LA compared with OA, though other studies disagreed with the finding [8, 9]. Subsequent studies have, however, disproved the concerns about increased postoperative complications in complicated appendicitis, with some demonstrating lower complications, length of hospital stay, and need for fewer follow-up visit with LA [10–17]. While most of the studies were small in size and retrospective in nature, they strongly suggest that outcomes following LA for complicated appendicitis are not inferior to those obtained with OA. Furthermore, a recent randomized clinical trial (RCT) comparing LA to OA in 23 children with generalized peritonitis as a result of perforated appendicitis concluded that LA may be superior to OA in this subset [18]. That notwithstanding, the acceptance of LA as first line treatment in all presentations of appendicitis will probably require a very large sample RCT with a national scope across different sizes and type of hospitals. In lieu of this, we set out to analyze a national database to determine the trend in use of LA *versus* OA in children with complicated appendicitis, and predictors of LA as a procedure of choice over OA in children with complicated appendicitis.

METHODS

A 10-y retrospective analysis of the Nationwide Inpatient Sample (NIS) database from 1998 to 2007 and the Kids' Inpatient Database (KID) (2000, 2003, and 2006) was performed. The NIS is the largest all-payer inpatient care database with approximately 8 million hospital stays each year from up to 40 states, and is part of the Healthcare Cost and Utilization Project (HCUP). It has a 20% stratified sample of U.S. community hospitals with the sampling frame being 90% of all hospital discharges in the United States. Data from the NIS can be weighted to give national estimates. Similarly, KID is part of the HCUP data armamentarium and contains data from hospital inpatient stays for approximately 2 to 3 million pediatric hospital discharges. Both NIS and KID contain clinical and nonclinical information, including primary and secondary diagnoses, procedures, patient demographics, expected payment source, total charges, length of stay, and various hospital characteristics. NIS data years for which the KID data were available were not included in the analysis to avoid duplication of records. The NIS and KID data were combined to create an uninterrupted yearly trend of data, which would otherwise not be possible with KID data alone.

Inclusion criteria were pediatric patients <18 y of age, who had a complicated appendicitis as defined by the appropriate International Classification of Disease 9 Clinical Modification (ICD 9 CM) codes: 540.0 and 540.1. Since these were discharge records, the diagnosis of complicated appendicitis as coded in this dataset would have been based on postop diagnosis, thereby eliminating patients with other potentially confounding diagnoses. These were further stratified by type of appendectomy: open (OA), code 47.09 *versus* laparoscopic (LA), code 47.01. Patients were classified by gender, ethnicity (Caucasian, African-American, Hispanic, Asian, Native American, and other), and insurance status (insured *versus* uninsured). Patient demographic characteristics, hospital length of stay (LOS), hospital total charges, postoperative complication rates, and in-hospital mortality were analyzed and compared by type of surgery (LA *versus* OA). Bivariate analysis was conducted using Pearson's χ^2 for categorical variables and Student's *t*-test for continuous variables with a level of significance set at 0.05. Using the HCUP provided weights, nationwide estimates were then calculated. The outcomes of interest were mortality, hospital charges and LOS. Multivariate regression was used to control for patient level characteristics (age, gender, race, insurance,) and type of surgery performed. In the adjusted analysis for hospital charges and LOS as outcomes, records with fatality were excluded so as not to skew the results.

RESULTS

A total of 72,787 cases of complicated appendicitis met the inclusion criteria. This represented approximately a quarter million (226,606) cases across the United States after applying appropriate weights based on HCUP sampling methodology. The median age was 11 y, with an interquartile range (IQR) of 7–14 y. The majority of cases was male (59.9%) and insured (89.7%). Of the operative procedures, OA accounted for two-thirds (70.8%) and LA 29.2%. Caucasians composed 38.2% of the study population, with Hispanics making up 24.8% and African-Americans 5.5%. The overall mortality was 4/10,000 appendectomies (Table 1).

On bivariate analysis, patients undergoing LA were significantly older by 1 y (10.1 *versus* 11.1 y, $P < 0.0001$) compared with those undergoing OA. The proportion of females was higher in the LA subset (41.3% *versus* 37.7%, $P < 0.001$). The mortality was higher in the OA group (7/10,000) compared with the LA group (1/10,000, $P = 0.005$) though overall mortality was still low at 4/10,000 regardless. Patients undergoing LA had

TABLE 1

Demographic Characteristics of Patients Undergoing Open and Laparoscopic Appendectomy, *n* = 72,787

	%
Gender	
Male	59.9
Female	37.8
Unknown	2.3
Age	
Median (interquartile range)	11 (7–14)
Race	
Caucasian	38.1
African-American	5.5
Hispanic	24.8
Asian or Pacific Islander	1.9
American Indian/Alaska	0.5
Other	3.5
Unknown	25.6
Insurance	
Insured	89.7
Uninsured	0.4
Unknown	9.9
Deaths	0.04
Appendectomy Type	
Laparoscopic	29.2
Open	70.8