Assessing outcomes and costs of appendectomies performed at rural hospitals ☆

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ARTICLE INFO

ABSTRACT

Background: The purpose of our study was to assess the outcomes and costs of appendectomies performed at rural and urban hospitals.
Methods: The National Inpatient Sample (2001—2012) was queried for appendectomies at urban and rural hospitals. Outcomes (disease severity, laparoscopy, complications, length of stay (LOS), and cost) were analyzed.
Results: Rural patients were more likely to be older, male, white, and have Medicaid or no insurance. Rural hospitals were associated with higher negative appendectomy rates ($OR = 1.26, 95\%CI = 1.18 -1.34, p < 0.01$), less laparoscopy use ($OR = 0.65, 95\%CI = 0.58-0.72, p < 0.01$), and slightly shorter LOS ($OR = 0.98, 95\%CI = 0.97-0.99, p < 0.01$). There was no consistent association with perforated appendicitis and no difference in complications or costs after adjusting for hospital volume. Yearly trends showed a significant increase in the cases utilizing laparoscopy each year at rural hospitals.
Conclusions: Rural appendectomies are associated with increased negative appendectomy rates and less laparoscopy use with no difference in complications or costs compared to urban hospitals.

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Introduction

Limited access to health care is associated with poor outcomes following appendectomy.[1–3] Rural hospitals serve patients with social and geographic barriers that may delay presentation and subsequently have a negative effect on morbidity and cost.[1–4] Additionally, rural populations tend to be older, poorer, less educated, and uninsured.[5] Rural surgeons and health systems also face a myriad of unique challenges, including the worsening deficit of surgeons in rural America, limited resources, and patients bypassing local hospitals in favor of urban hospitals due to concerns regarding quality of care.[5,6] In response to these issues threatening closure of rural hospital systems, certain rural hospitals have been designated as Critical Access Hospitals by the Medicare Rural Hospital Flexibility Program to help financially support these institutions and improve access to care.[5–8]

Critical Access Hospitals now comprise 29% of acute care hospitals in the United States.[9,10] This growth has generated increasing interest in the quality and cost of care provided by rural and Critical Access Hospitals. Many studies question the quality of care compared to urban hospitals.[11–13] Although a few studies suggest no difference in quality of care,[8,14,15] little is known about the outcomes of common general surgery procedures, such as appendectomy, at rural hospitals.

Thus, the purpose of our study was to assess the differences in outcomes and costs of appendectomies performed at rural and urban hospitals within the United States. We hypothesized that rural hospitals treat patients with higher disease severity with no difference in outcomes compared to patients treated at urban centers.

Materials and methods

Data source

The National (Nationwide) Inpatient Sample (NIS) from the Healthcare Cost and Utilization Project (HCUP) and Agency for Healthcare Research and Quality (AHRQ) comprises of data from inpatient hospital stays across the United States.[16] The database includes data from 4378 hospitals in 44 states, including basic hospital characteristics, patient demographics, insurance status, diagnoses, procedures performed, hospital length of stay (LOS), and total charges. Rural or urban hospital designation in NIS is determined by Core Based Statistical Area (CBSA) codes, which are based on 2000 and 2010 Census data.[17,18] Hospital bed size (small, medium, or large) was categorized in NIS (see Table 1) based on the number of hospital beds, hospital region (Northeast, Midwest, South, West), hospital designation (urban or rural), and teaching status. Hospital volume was determined based on the annual number of appendectomies performed at each hospital. Our sample was divided into four quartiles at the hospital level. The 1st quartile represents low-volume hospitals (1–43 appendectomy cases per year), the two middle quartiles represent medium-volume hospitals (2nd quartile 44–84 cases per year, 3rd quartile 85–145 cases per year), and the 4th quartile represents high-volume hospitals (>146 cases per year).

Study population

We queried the NIS database from 2001 to 2012 for all adults aged 20 to 69 who underwent non-incidental appendectomy as their primary procedure. International Classification of Diseases, Ninth Revision (ICD-9) procedure codes 47.01 (laparoscopic appendectomy) and 47.09 (other appendectomy) were used to identify inpatient hospitalizations. Each patient was then stratified into rural and urban cohorts.

Outcomes

Primary outcomes analyzed in this study included disease severity, laparoscopy use, complications, LOS, and cost. Disease severity for non-incidental appendectomies was categorized as: negative appendectomy; appendectomy for acute, non-perforated appendicitis; or appendectomy for perforated appendicitis. A negative appendectomy was defined as a non-incidental appendectomy without a diagnosis of appendicitis or an appendectomy

where appendicitis was not among the first three diagnoses.[19,20] Acute, nonperforated appendicitis was identified with ICD-9 codes 540.9 (acute appendicitis without mention of peritonitis), 541 (appendicitis, unqualified), and 542 (other appendicitis). Perforated appendicitis was identified by ICD-9 codes 540.0 (acute appendicitis with generalized peritonitis) or 540.1 (acute appendicitis with peritoneal abscess).

Common complications associated with appendectomy were investigated using appropriate ICD-9 codes. This included infectious, intestinal, and other miscellaneous complications. Other miscellaneous complications included renal failure, postoperative respiratory complications (atelectasis, pneumonia, pneumothorax, acute respiratory insufficiency), and postoperative cardiovascular complications (deep vein thrombosis, pulmonary embolus, postoperative stroke, cardiac arrest).

Length of stay was determined as total number of days during the hospital admission where appendectomy was performed. Cost was derived from charges using the charge-to-cost ratio files provided by HCUP[21] and published medical consumer price index. The cost was adjusted to represent 2010 dollars to account for inflation and was then logarithmically transformed to account for the right skew in the data.

Statistical analysis

Bivariate and multivariable regression analyses were performed on the rural and urban cohorts. Three step-wise multivariate analyses were performed with different covariates to evaluate the effect of rural hospital designation on the primary outcomes. The first multivariate analysis corrected for demographic factors, including age, gender, race/ethnicity, insurance type, and year of procedure. The second regression analysis included hospital bed size in addition to the previously listed covariates, and the third analysis controlled for hospital case volume. Laparoscopy and complication rates were also controlled for if they were not the primary outcome measured. All data analyses were conducted using Stata Statistical Software: Release 14.2 (StataCorp. 2015. College Station, TX: StataCorp LP). P-values < 0.05 were considered significant.

Results

A total of 2,268,166 patients underwent non-incidental appendectomy between 2001 and 2012. Patient demographics for rural (n = 308,924) and urban (n = 1,959,242) patients are summarized in Table 2. The majority of appendectomies (86.4%) were performed at urban hospitals. There was a slight predominance of male patients at both rural and urban hospitals. Rural patients were more likely to be older, male (54.6% vs 53.3%, P < 0.01), and white (83.4% vs 77.5%, P < 0.01). Rural hospitals treated higher proportions of Medicaid and uninsured patients (35.5% vs. 29.5%, P < 0.01).

Analysis of the regional hospital distribution (see Table 2) showed variations nationwide. Rural patients were mostly treated at hospitals located in the South (39.8%) and Midwest (30.7%), while urban patients were mostly treated at hospitals in the South (33.1%) and West (26.5%). Both rural and urban appendectomy patients were predominantly managed at large hospitals (66.9% rural vs 58.3% urban, P < 0.01), followed by medium-sized hospitals (20.9% vs 28.3%, P < 0.01), and less frequently at small hospitals (12.1% vs 13.5%, P < 0.01). See Table 1 for NIS designations for hospital bed size. The majority of rural patients (72.2%) were treated at low-volume hospitals (0–43 appendectomy cases per year), while only 0.2% of rural patients were treated at high-volume hospitals (>146 cases per year). In contrast, there was a more even distribution of urban appendectomy patients treated at high-, medium-, and low-volume hospitals (see Table 2).

Table 1
Hospital size categories by region (HCUP NIS designations).

Location, Teaching Status	Hospital Bed Size		
	Small	Medium	Large
Northeast			
Rural	1–49	50–99	>100
Urban, non-teaching	1–124	125–199	>200
Urban, teaching	1–249	250–424	>425
Midwest			
Rural	1–29	30–49	>50
Urban, non-teaching	1–74	75–174	>175
Urban, teaching	1–249	250–374	>375
South			
Rural	1–39	40–74	>75
Urban, non-teaching	1–99	100–199	>200
Urban, teaching	1–249	250–449	>450
West			
Rural	1–24	25–44	>45
Urban, non-teaching	1–99	100–174	>175
Urban, teaching	1–199	200–324	>325

Table 2
Patient demographics.

	Rural (n = 308,924)	Urban (n = 1,959,242)	P-value
Male	54.6%	53.3%	<0.01
Age Group			
20-29	30.1%	29.1%	<0.01
30-39	24.8%	23.7%	
40-49	20.8%	20.5%	
50-59	15.3%	16.7%	
60-69	8.9%	11.0%	
Race			
White	83.4%	77.5%	<0.01
Black	4.2%	0.7%	
Hispanic	7.0%	12.1%	
Other	5.4%	9.7%	
Insurance			
Private	58.4%	64.5%	<0.01
Public	19.1%	15.9%	
No insurance	16.4%	13.6%	
Other	6.2%	6.1%	
Hospital Region			
Northeast	13.1%	22.0%	<0.01
Midwest	30.7%	18.5%	
South	39.8%	33.1%	
West	16.5%	26.5%	
Hospital Size			
Small	12.1%	13.5%	<0.01
Medium	20.9%	28.3%	
Large	66.9%	58.3%	
Hospital Case Volume (cases per year)			
Low-volume, 1st Quartile (0–43)	72.2%	18.4%	<0.01
Medium-volume, 2nd Quartile (44–84)	24.2%	25.1%	
Medium-volume, 3rd Quartile (85–145)	3.4%	28.0%	
High-volume, 4th Quartile (>146)	0.2%	28.5%	

Bivariate analyses of patient outcomes and costs are shown in Table 3. Rural patients were more likely to undergo negative appendectomy (5.7% vs 4.2%, P < 0.01) and present with perforated appendicitis (27.0% vs 23.7%, P < 0.01). Rural hospitals had lower utilization of laparoscopy (49.5% vs 61.6%, P < 0.01), increased overall complications (6.9% vs 5.5%, P < 0.01), slightly longer median LOS by 0.16 days (2.74 vs 2.58 days, P < 0.01), and increased median costs by $814 per patient ($8872 vs $8,058, P < 0.01).

Three step-wise multivariate analyses are summarized in Table 4. Multivariate analysis correcting for age, gender, race/ethnicity, year of procedure, and insurance status demonstrated that rural patients were associated with higher negative appendectomy rates (OR 1.26, 95% CI 1.18–1.34, P < 0.01), but had no significant difference in appendiceal perforation rates compared to urban patients. Rural hospitals were associated with decreased laparoscopy use (OR 0.65, 95% CI 0.58–0.72, P < 0.01), higher complication rates (OR 1.10, 95% CI 1.03–1.16, P < 0.01), slightly shorter LOS (OR 0.98, 95% CI 0.97–0.99, P < 0.01), and increased costs (OR log 0.08, 95% CI 0.06–0.11, P < 0.01).

When hospital size was included as a covariate in the multivariate analysis, rural hospitals were now associated with slightly higher rates of perforated appendicitis (OR 1.05, 95% CI 1.00–1.09, P < 0.05). Otherwise, findings were similar with rural hospitals associated with higher negative appendectomy rates, decreased utilization of laparoscopy, higher complication rates, slightly shorter LOS, and increased costs.

Multivariate analysis with hospital volume as a covariate instead of hospital size yielded slightly different findings from the previous two analyses. Rural hospitals were now associated decreased rates of perforated appendicitis (OR 0.92, 95% CI 0.87–0.96, P > 0.01) and no significant difference in complication rates nor cost when compared to urban hospitals. In all three analyses, rural hospitals were consistently shown to be associated with higher negative appendectomy rates, less utilization of laparoscopy, and shorter LOS.

Analysis of the yearly trends in laparoscopy use in rural hospitals showed an overall increase in the proportion of cases utilizing laparoscopy each year. In 2001, 31% of appendectomy cases utilized laparoscopy. By 2012, there was a significant increase in the utilization of laparoscopy with 71% of rural appendectomy cases performed laparoscopically.

Table 3
Bivariate analysis of outcomes and costs.

	Rural	Urban	p-value
Negative Appendectomy	5.7%	4.2%	<0.01
Perforated Appendicitis	27.0%	23.7%	<0.01
Laparoscopy	49.5%	61.6%	<0.01
Complications	6.9%	5.5%	<0.01
Gastrointestinal	3.9%	3.1%	
Infectious	1.2%	1.0%	
Other	1.7%	1.4%	
Median LOS (days), median (IQR)	2.74 (2.70–2.78)	2.58 (2.56–2.61)	<0.01
Median Cost ($), median (IQR)	8872 (8683–9061)	8058 (7950–8165)	<0.01

Table 4
Multivariate analysis of rural compared to urban hospitals.

	Urban Hospitals	Rural Hospitals	Rural Hospitals (+Hospital Size)	Rural Hospitals (+Hospital Volume)
Negative Appendectomy	1 (Reference)	1.26 (1.18–1.34)**	1.26 (1.18–1.35)**	1.13 (1.05–1.21)**
Perforated Appendicitis	1 (Reference)	1.04 (1.00–1.09)	1.05 (1.00–1.09)*	0.92 (0.87–0.96)**
Laparoscopy	1 (Reference)	0.65 (0.58–0.72)**	0.64 (0.57–0.72)**	0.70 (0.62–0.79)**
Complications	1 (Reference)	1.10 (1.03–1.16)**	1.10 (1.04–1.17)**	0.99 (0.93–1.06)
Length of Stay (IRR)	1 (Reference)	0.98 (0.97–0.99)**	0.98 (0.97–0.99)**	0.95 (0.94–0.97)**
Cost (log %)	1 (Reference)	0.08 (0.06–0.11)**	0.09 (0.06–0.11)**	0.01 (−0.01–0.04)

Values reported as odds ratio (95% confidence interval) unless otherwise specified; IRR = incident rate ratio * P < 0.05, **P < 0.01.

Discussion

Patients undergoing non-incidental appendectomy at rural hospitals have higher negative appendectomy rates, lower rates of laparoscopy use, and slightly shorter LOS compared to urban hospitals. Although our findings initially suggested that rural hospitals were associated with increased complications and higher costs, these were not found to be significant when correcting for hospital volume. Yearly trends showed a significant annual increase in the proportion of cases utilizing laparoscopy each year at rural hospitals. Our findings suggest that rural hospitals can safely perform appendectomies, but have different practices with regards to diagnosis of appendicitis and utilization of laparoscopy compared to their urban counterparts.

Our analysis showed that rural patients were more likely to have a negative appendectomy, which is consistent with a study by Oyetunji et al.[22] This association persisted after controlling for hospital size or volume and may be explained by different practices in diagnosis of appendicitis at rural hospitals. The increased sensitivity of imaging techniques has led to decreased negative appendectomy rates.[20,23,24] However, rural hospitals may lack available diagnostic imaging modalities or have financial constraints that limit preoperative imaging. Historically, negative appendectomies were considered low morbidity and low cost, and were justified to decrease the delay in diagnosis and risk of perforated appendicitis.[2] This scenario may still hold true at rural hospitals. Another consideration is the pressure to operate on a patient with suspected pathology may be greater in the rural setting, since patients must often make great efforts to travel long distances to the hospital and may not be able to follow-up as easily. A study by Turrentine et al. on rural patients found that for every 10 min of travel time from the patient's home to the hospital, there was a 9% increase in probability for readmission.[25]

In our study, we did not find a conclusive association between rural patients and perforated appendicitis. Perforated appendicitis is a multifactorial disease process with presentation time, patient characteristics, and socioeconomic factors all implicated as risk factors.[1,2,26] In addition to our study, there have only been two other studies that have investigated the rates of perforated appendicitis in adult rural populations in the United States.[1,26] Drake et al. found no association between rural hospital setting and appendiceal perforation rates.[26] Meanwhile, Paquette et al. found rural residence to be an independent predictor of perforation (OR 1.11), but did not adjust for hospital size nor volume in their analysis.[1] Our multivariate analyses of rural hospitals showed no association with perforated appendicitis when only patient demographics were adjusted for, increased association when hospital size was included as a covariate, and decreased association when hospital volume was replaced as a covariate. The divergent findings amongst these studies may be due to differences in study populations, data sources, study designs, characteristics of treatment settings, or other patient factors that haven't been studied. Further studies are needed to characterize perforated appendicitis in rural populations.

The lower rates of laparoscopy use in rural hospitals may be due to the unique financial and technologic constraints imposed on rural centers that are not normally encountered at urban hospitals. Additionally, rural surgeons tend to be older with 52% of the general surgeons in rural areas aged 50–62 in 2005,[27] and may be more facile with performing an open appendectomy. A study by Van Hove et al. found that rural and urban hospitals performed laparoscopic appendectomy at nearly equal rates in 1997, but urban hospitals adopted laparoscopy much more quickly each year.[28] Our analysis showed that high-volume hospitals were 27% more likely to utilize laparoscopy compared to low-volume hospitals. However, only 0.2% of rural patients were treated at high-volume hospitals. Our analysis of trends in laparoscopy use showed an annual increase in the utilization of laparoscopy at rural hospitals each year. Laparoscopy use has been linked to economic, clinical, and sociologic patient factors. Rural surgeons may not be as inclined to perform laparoscopy if their hospital has older, cart-based laparoscopic equipment that would take longer to set up or would be more costly. A recent study by Cronen et al. analyzed laparoscopic appendectomies performed at a rural hospital in Indiana and found that laparoscopic appendectomy was on average $2600 more expensive per patient than an open appendectomy, but did not provide a significant decrease in LOS to justify its use for all patients with appendicitis.[29]

On all three multivariate analyses, LOS was significantly shorter in rural hospitals compared to urban hospitals. However, the actual difference on bivariate analysis was 0.16 days, which is of limited clinical significance. Other studies have also shown shorter LOS at rural hospitals.[8,15] The LOS in rural hospitals may be shorter as critical access hospitals are required to have an annual average of 96 h or less for acute inpatient stays.[7]

After adjusting for hospital volume in addition to age, gender, race/ethnicity, year of procedure, and insurance status, we found no significant difference in the complication rates or cost when compared to urban hospitals. Without adjusting for hospital volume, rural appendectomies were associated with a 10% increase in complications and 8% increase in costs compared to urban hospitals. Hospital volume has been extensively studied for a variety of procedures and is associated with improved postoperative outcomes.[2,19] McAteer et al. demonstrated increased postoperative complications in pediatric appendectomy patients at rural hospitals,[14] but did not account for hospital case volume in their analysis. Prior studies on costs are inconclusive, with some studies showing higher costs[8] and others showing lower costs,[15] but these studies also did not adjust for hospital case volume. Given that 72.2% of rural appendectomies were performed at low-volume hospitals, it may not be justified to simply compare rural to urban hospitals without accounting for hospital volume. Our findings show that there is no difference between the complication rates and costs between low-volume rural and urban hospitals. The inherent social and geographic isolation unique to rural populations does not

support the development of high-volume hospitals in rural areas. This highlights the issue of hospital regionalization and further optimization for models of rural surgical care.[30]

The study limitations are mainly associated with using a large retrospective administrative database. The accuracy of the diagnosis and complications is based solely on billing codes. The NIS database has limited access to ancillary data, such as details of the patient's history and presentation to assess for severity and duration of symptoms. The NIS Database does not track if the subject had issues with access to medical care or the specific barriers they encountered. We were also unable to control for the bypass effect in our study (i.e. rural patients presenting to urban hospitals). The lack of data on surgeon characteristics, operative details, laboratory values, imaging results, associated hospital visits after discharge, and readmission data limits our ability to further analyze our findings. While the NIS database allows a large sample size this leads to all differences becoming statistically significant, even though they may not be clinically significant. We also realize that there are unique differences in rural populations across the United States, and that our study based on national data may not be generalizable to each rural community.

Conclusions

Appendectomies can be safely performed in rural patients with no difference in complication rates or costs. Hospital volume should be taken into consideration when comparing patient outcomes and costs, given the distinct differences between rural and urban hospital systems and the patients they serve. Regardless, there are practice variations in the diagnosis of appendicitis and utilization of laparoscopy. Rural appendectomies were associated with increased rates of negative appendectomy and decreased laparoscopy use. There was a significant annual increase in the use of laparoscopy for the management of appendicitis in rural patients during the study period. Further studies are needed to identify patient, surgeon, and hospital factors to develop and refine viable models of rural surgical care. Optimization of resource allocation and regionalization of hospitals may be required to rectify the disparities in rural surgical care across America for this common surgical disease.

Summary for table of contents

Rural hospitals serve patients with social and geographic barriers that may delay presentation and subsequently have a negative effect on postoperative morbidity and cost. The purpose of our study was to assess the differences in outcomes and costs of appendectomies performed at rural and urban hospitals. Rural patients were more likely to be older, male, white, and have Medicaid or no insurance. After adjusting for hospital volume, rural appendectomies are associated with increased negative appendectomy rates and less laparoscopy use with no difference in complications or costs compared to urban hospitals.

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