ORIGINAL ARTICLE

Outcomes From 3144 Adrenalectomies in the United States

Which Matters More, Surgeon Volume or Specialty?

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Objective: To assess the effect of surgeon volume and specialty on clinical and economic outcomes after adrenalectomy.

Design: Population-based retrospective cohort analysis.

Setting: Healthcare Cost and Utilization Project Nationwide Inpatient Sample.

Participants: Adults (≥18 years) undergoing adrenalectomy in the United States (1999-2005). Patient demographic and clinical characteristics, surgeon specialty (general vs urologist), surgeon adrenalectomy volume, and hospital factors were assessed.

Main Outcome Measures: The χ^2 test, analysis of variance, and multivariate linear and logistic regression were used to assess in-hospital complications, mean hospital length of stay (LOS), and total inpatient hospital costs.

Results: A total of 3144 adrenalectomies were included. Mean patient age was 53.7 years; 58.8% were women and 77.4% white. A higher proportion of general surgeons were high-volume surgeons compared with urologists (34.1% vs 18.2%, $P<.001$). Low-volume surgeons had more complications (18.2% vs 11.3%, $P<.001$) and their patients had longer LOS (5.5 vs 3.9 days, $P<.001$) than did high-volume surgeons; urologists had more complications (18.4% vs 15.2%, $P=.03$) and higher costs ($13 168 vs $11 732, $P=.02$) than did general surgeons. After adjustment for patient and provider characteristics in multivariate analyses, surgeon volume, but not specialty, was an independent predictor of complications (odds ratio = 1.5, $P<.002$) and LOS (1.0-day difference, $P<.001$). Hospital volume was associated only with LOS (0.8-day difference, $P<.007$). Surgeon volume, specialty, and hospital volume were not predictors of costs.

Conclusion: To optimize outcomes, patients with adrenal disease should be referred to surgeons based on adrenal volume and laparoscopic expertise irrespective of specialty practice.

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THE PREVALENCE OF INCIDENTAL adrenal masses is estimated to be 4% to 7% of the US population.[1-3] With more frequent use and improved resolution of computed tomography and a lowered threshold for surgery with laparoscopy, the rate of adrenalectomy has risen steadily over the past 20 years. One study[4] reported a 43% increase from 1988 to 2000. Although adrenalectomy is associated with low mortality (<1%) and improved outcomes from minimally invasive techniques, recent studies[5-8] report complication rates of 8% to 19% and a mean hospital length of stay (LOS) of 2 to 8 days.

Increased surgeon volume has been shown to be positively associated with improved patient outcomes after several other operations, including thyroidectomy, parathyroidectomy, coronary artery bypass grafting, aortic valve replacement, abdominal aortic aneurysm repair, bariatric surgery, pancreaticoduodenectomy, and esophagectomy.[9-18] Two studies[19,20] of the impact of surgeon volume on outcomes after adrenalectomy using state hospital discharge data found no association between surgeon volume and complication rates but did find a robust association between high surgeon volume and shorter LOS.

Concerns have been raised that graduates from general surgery and urology residency training programs are inadequately trained in adrenalectomy, particularly using laparoscopic techniques.[21-23] To date, to our knowledge, no published studies have compared these surgical specialties by adrenal operative experience or outcomes; therefore, it is unknown whether surgeon specialty is associated with their patients' outcomes. This study is the first population-based analysis of clinical and

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economic outcomes after adrenalectomy in the United States and the first to examine the independent effects of surgeon volume and specialty on patient clinical and economic outcomes.

METHODS

DATA SOURCE

This study is a retrospective cohort analysis of 1999 through 2005 hospital discharge information from the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (HCUP-NIS) database, which is maintained by the Agency for Healthcare Research and Quality. The HCUP-NIS is the largest all-payer inpatient database publicly available in the United States, approximating a 20% stratified sample of all US nonfederal hospitals.[24] Adult patients (≥18 years) undergoing adrenalectomy were the focus of the analysis. Adrenalectomy procedures were selected based on their *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* procedure code, including partial (excision of a lesion and other), unilateral, and bilateral adrenalectomy.

INDEPENDENT VARIABLES

The 2 primary independent variables, surgeon volume and specialty, were modeled as categorical variables. Surgeons must have performed at least 1 adrenalectomy during the study period to be included in the analysis. Surgeon volume was based on the annual number of adrenal procedures. High-volume surgeons were in the top quartile based on the number of adrenalectomies they performed per year (≥4). Surgeons were defined as urologists if they performed at least 1 urologic procedure per year, including cystoscopy, prostatectomy, ultrasonic fragmentation of urinary stones, and extracorporeal shockwave lithotripsy. These procedures were believed to represent a body of procedures that specialty-trained urologists would perform commonly but not exclusively. All other surgeons in the analysis were defined as general surgeons. There is no specific definition in the HCUP-NIS for surgeon specialty; therefore, this proxy was used.

Independent patient demographic variables included age, sex, ethnicity (white, African American, Hispanic, and other, which included but was not limited to Asians, Pacific Islanders, and Native Americans), median household income, and primary payer (private/health maintenance organization [HMO], Medicaid, self-pay, Medicare, no charge, and other). Between 1999 and 2002, categories for median household income were $1 to $24 999 (low), $25 000 to $34 999 (medium-low), $35 000 to $44 499 (medium), and $45 000 or more (high); between 2003 and 2005, the categories were $1 to $35 999 (low), $36 000 to $44 999 (medium-low), $45 000 to $59 000 (medium), and $59 000 or more (high). Independent clinical variables included principal procedure (partial, unilateral, and bilateral adrenalectomy), principal diagnosis (benign vs malignant), type of admission (routine vs nonroutine), comorbidity, and surgical technique (open vs laparoscopic). Comorbidity scores were calculated using an adaptation of the Charlson Comorbidity Index.[25] Charlson Comorbidity Index scores of 0 and 1 were categorized as low, 2 and 3 as medium-low, 4 and 5 as medium, and 6 or greater as high. Although there was no unique *ICD-9-CM* procedure code for laparoscopic adrenalectomy, the code for laparoscopy of the abdominal regions (*ICD-9-CM* procedure code 54.21) was used with the code for adrenalectomy to identify laparoscopic adrenalectomy. Hospital-provider variables included hospital region (Northeast, Midwest, South, and West), location (urban and rural), teaching status (teaching and nonteaching), volume, and period (1999-2002 and 2003-2005). High-volume hospitals were in the top quartile based on the number of adrenalectomies performed there per year (≥14). All independent variables were treated as categorical variables except for age, which was modeled as a continuous variable.

OUTCOME VARIABLES

The outcomes of interest were in-hospital complications, mean hosptial LOS, and total inpatient hospital costs. Complications were categorized as hemorrhagic, infectious/wound, technical, endocrine (such as adrenocortical insufficiency), cardiovascular, renal, or pulmonary. Information regarding complication severity was unavailable, so complications were treated as a dichotomous variable (0 vs ≥1). Total inpatient costs were calculated using HCUP-NIS–adjusted, hospital-specific cost-to-charge ratios. Costs were then adjusted for inflation, converting all costs to 2005 US dollars using rates from the Bureau of Labor Statistics.[26]

STATISTICAL ANALYSIS

Bivariate analyses of the independent variables with the outcomes of interest were performed using the χ^2 test for categorical variables and analysis of variance for the continuous variable (age). Multivariate linear regression models were used to adjust for significant independent variables for LOS and total inpatient hospital costs, and multivariate logistic regression models were used to adjust for independent variables for in-hospital complications. These analyses adjusted for demographic and clinical patient and provider distributions. A backward elimination procedure was applied for independent variable selection. Data analysis and management were performed using a statistical software program (SPSS version 16.0; SPSS Inc, Chicago, Illinois). All tests were 2-sided, with significance set at $P \leq .05$. This study was granted exemption from institutional review board approval at Yale University School of Medicine because the HCUP-NIS is a public database with no personal identifying information.

RESULTS

PATIENT AND PROVIDER CHARACTERISTICS

Between January 1, 1999, and December 31, 2005, 5847 adult patients were identified in the HCUP-NIS database as having a principal procedure code for adrenalectomy. In 1999, there were 759 patients with a principal procedure code for adrenalectomy. There were 7 198 929 hospital discharges in 1999, yielding a rate of 10.5 adrenalectomies per 100 000 discharges. By 2005, there were 1125 patients with a principal procedure code for adrenalectomy; given that there were 7 995 048 hospital discharges in 2005, there were 14.1 adrenalectomies per 100 000 discharges. This suggests a 26% increase in the number of adrenalectomies performed in the United States from 1999 to 2005.

Surgeon identifiers were available for 3389 patients (58%). No significant differences were noted between patients with or without surgeon identifiers regarding other demographic and clinical characteristics. Because of a miscoding error of adrenal lesion excisions in 2000, 175 pa-

Table 1. Characteristics of Patients Undergoing Adrenalectomy by Surgeon Volume and Specialty

Characteristic	Total, % (N=3144)	Surgeon Volume, %			Surgeon Specialty, %		
		Low (n=2214)	High (n=930)	*P* Value	General (n=2253)	Urologist (n=891)	*P* Value
Age, mean (SD), y	54 (14)	54 (14)	52 (14)	<.001	53 (14)	55 (13)	.009
Female sex	58.8	57.3	62.5	.008	60.3	55.2	.01
Race				<.001			.17
White	77.4	75.2	82.4		77.5	77.0	
African American	12.4	13.7	9.4		11.9	13.6	
Hispanic	6.3	7.2	4.1		6.1	6.6	
Other	4.0	3.9	4.1		4.4	2.8	
Median household income				.11			.12
Low	13.8	13.7	14.2		13.8	13.9	
Medium low	24.7	23.8	26.9		24.3	25.6	
Medium	27.0	28.1	24.4		26.2	29.1	
High	34.4	34.4	34.5		35.7	31.3	
Primary payer				.04			.45
Private/HMO	61.9	60.6	64.8		62.2	61.1	
Medicare	25.5	27.1	21.6		24.6	27.7	
Medicaid	7.0	6.6	8.0		7.2	6.3	
Self-pay	2.5	2.6	2.4		2.7	2.0	
No charge	0.7	0.6	0.8		0.7	0.6	
Other	2.5	2.5	2.5		2.5	2.4	
Principal procedure				<.001			.01
Partial	8.3	9.4	5.7		8.7	7.2	
Unilateral	89.2	88.8	90.4		88.4	91.5	
Bilateral	2.4	1.9	3.9		2.9	1.3	
Laparoscopy	14.4	10.7	23.1	<.001	15.3	12.1	.02
Malignant principal diagnosis	17.9	20.3	12.4	<.001	16.6	21.2	.003
Routine admission	95.1	94.9	95.3	.72	94.6	96.1	.08
Charlson Comorbidity Index score				.009			.93
Low	67.0	65.4	70.8		67.3	66.2	
Medium low	23.0	23.9	20.9		22.8	23.7	
Medium	4.7	4.7	4.6		4.7	4.6	
High	5.3	6.0	3.8		5.2	5.5	

Abbreviation: HMO, health maintenance organization.
[a] Due to rounding percentages may not total 100%.

tients were excluded in addition to the 70 excluded based on the likelihood that the adrenalectomies were performed as part of a radical nephrectomy (a primary or secondary diagnosis of renal cell carcinoma or a primary or secondary procedure of nephroureterectomy without a primary diagnosis of adrenal malignant neoplasm).

A total of 3144 adrenalectomies were included in the analysis. The mean patient age was 54 years, and most patients were female (59%), white (77%), and insured by a private insurance carrier or an HMO (62%). Eighty-nine percent of patients underwent unilateral adrenalectomy, 18% of principal diagnoses were malignant neoplasms, and 14% of the procedures were simultaneously coded for laparoscopy of the abdomen (**Table 1**). Most procedures were performed at urban (95%) and teaching (67%) hospitals (**Table 2**).

Compared with low-volume surgeons, high-volume surgeons tended to operate on patients who were younger, female, white, and insured by a private insurance carrier or an HMO. High-volume surgeons performed more bilateral adrenalectomies and used more laparoscopy, although their patients had a lower rate of malignancy and fewer comorbidities (Table 1). High-volume surgeons operated more frequently at urban, teaching, and high-volume hospitals (Table 2).

There were 891 adrenalectomies performed by urologists (28%). Compared with urologists, a higher proportion of general surgeons were high volume (34% vs 18%, $P<.001$) (Table 2). General surgeons tended to operate on patients who were younger and female. They also performed more bilateral adrenalectomies, used more laparoscopy, and operated on patients with a lower rate of malignancy. No significant differences were noted between surgeon specialty groups by race, primary payer, or comorbidity (Table 1). General surgeons operated more frequently at teaching and high-volume hospitals (Table 2).

UNADJUSTED OUTCOMES

Adrenalectomy was associated with an overall complication rate of 16% (n=507). Pulmonary problems accounted for 39% of all complications, followed by hemorrhagic (34%), endocrine (12%), cardiovascular (12%), and renal (10%) events. The mean LOS after adrenalectomy was 5 days; the mean cost of a hospitalization associated with adrenalectomy was $12 173. In-hospital mortality was 0.5%.

There were several significant differences in unadjusted clinical and economic outcomes by patient (**Table 3**) and provider (**Table 4**) characteristics. Demographic groups with significantly higher complication rates

Table 2. Characteristics of Providers Performing Adrenalectomy by Surgeon Volume and Specialty

Characteristic	Total, % (n=3144)	Surgeon Volume, %			Surgeon Specialty, %		
		Low (n=2214)	High (n=930)	*P* Value	General (n=2253)	Urologist (n=891)	*P* Value
Geographic region							
Northeast	26.4	24.3	31.6		25.0	30.0	
Midwest	15.1	11.6	23.4	<.001	16.0	12.7	<.001
South	45.1	49.5	34.5		44.0	47.9	
West	13.4	14.6	10.4		15.0	9.4	
Urban hospital	95.1	94.0	97.5	<.001	95.3	94.5	.36
Teaching hospital	67.1	55.8	93.9	<.001	69.2	61.6	<.001
High hospital volume	23.1	10.0	54.2	<.001	26.1	15.6	<.001
Years: 2003-2005	50.7	45.8	62.3	<.001	47.8	57.9	<.001
High surgeon volume	29.6	NA	NA	NA	34.1	18.2	<.001
Urologist	28.3	32.9	17.4	<.001	NA	NA	NA

Abbreviation: NA, not applicable.

Table 3. Unadjusted Outcomes After Adrenalectomy by Patient Characteristics[a]

Characteristic	Complications		Length of Stay		Costs	
	%	*P* Value	Days	*P* Value	$10 000s	*P* Value
Age[b]		<.001		<.001		.89
Sex		.004		.50		.87
Male	18.4		5.0		12.2	
Female	14.5		5.0		12.1	
Ethnicity		.07		.84		.60
White	16.9		5.0		12.1	
African American	12.4		5.1		12.8	
Hispanic	18.4		5.4		13.5	
Other	10.7		4.8		10.6	
Median household income		.006		.52		.72
Low	14.8		5.1		11.6	
Medium low	17.9		5.1		11.8	
Medium	18.8		5.1		12.2	
High	13.4		4.8		12.6	
Primary payer		.02		<.001		.009
Private/HMO	14.6		4.4		11.5	
Medicare	20.1		6.1		13.7	
Medicaid	14.6		5.8		13.4	
Self-pay	16.5		6.8		9.7	
No charge	19.0		5.7		16.5	
Other	16.7		4.5		10.6	
Principal procedure		<.001		<.001		.001
Partial	16.5		5.5		11.9	
Unilateral	15.6		4.9		12.0	
Bilateral	33.8		7.2		19.1	
Surgical technique		<.001		<.001		<.001
Laparoscopic	6.2		2.8		9.2	
Open	17.8		5.4		12.7	
Principal diagnosis		<.001		<.001		<.001
Malignant	21.5		6.9		14.9	
Other	17.6		4.6		11.6	
Admission type		.001		<.001		<.001
Routine	15.5		4.6		11.6	
Nonroutine	26.6		12.9		25.1	
Charlson Comorbidity Index score		<.001		<.001		<.001
Low	13.4		4.3		10.8	
Medium low	19.5		5.7		13.2	
Medium	21.8		7.7		16.9	
High	30.5		9.0		21.0	

Abbreviation: HMO, health maintenance organization.
[a] For a detailed description of the various variables, see the "Independent Variables" subsection of the "Methods" section.
[b] Age is modeled as a continuous variable.

Table 4. Unadjusted Outcomes After Adrenalectomy by Provider Characteristics

Characteristic	Complications		Length of Stay		Costs	
	%	*P* Value	Days	*P* Value	$10 000s	*P* Value
Geographic region		.02		.06		.06
Northeast	13.4		5.2		13.4	
Midwest	14.8		4.6		11.3	
South	17.1		5.2		11.9	
West	19.7		4.6		12.1	
Hospital location		.26		.89		.88
Urban	16.0		5.0		12.2	
Rural	19.4		5.1		12.4	
Hospital teaching status		<.001		.001		.27
Teaching	14.5		4.8		12.4	
Nonteaching	19.5		5.4		11.7	
Hospital volume		.05		<.001		.47
High	13.8		4.1		11.8	
Low	16.8		5.3		12.3	
Years		.85		<.001		.02
1999-2002	16.3		5.5		11.2	
2003-2005	16.0		4.6		12.6	
Surgeon volume		<.001		<.001		.06
High	11.3		3.9		11.0	
Low	18.2		5.5		12.6	
Surgeon specialty		.03		.24		.02
Urologist	18.4		5.2		13.2	
General surgeon	15.2		4.9		11.7	

Table 5. Unadjusted Outcomes After Adrenalectomy by Surgeon Volume and Specialty

Outcome	High-Volume Surgeon				Low-Volume Surgeon				*P* Value, High vs Low Volume
	All	Urologist (n=162)	General (n=768)	*P* Value	All	Urologist (n=729)	General (n=1485)	*P* Value	
Complications, %	11.3	14.2	10.7	.22	18.2	19.3	17.6	.32	<.001
Length of stay, d	3.9	4.4	3.7	.12	5.5	5.4	5.6	.40	<.001
Cost, $10 000s	11.0	13.6	10.8	.07	12.6	13.0	12.3	.25	.06

included older individuals, men, patients with a lower median household income, and Medicare recipients, as well as bilateral adrenalectomy, open surgical technique, malignant neoplasms, nonroutine admission, and a high comorbidity score. Complications also were more common in the West and at nonteaching and low-volume hospitals. The LOS was significantly longer for older individuals and for patients with primary payer categorized as self-pay, bilateral adrenalectomy, open surgical technique, malignant neoplasm, nonroutine admission, and a high comorbidity score. Nonteaching and low-volume hospitals had a longer LOS. Costs were significantly higher for patients with primary payer categorized as no charge, bilateral adrenalectomy, open surgical technique, malignant neoplasm, nonroutine admission, and a high comorbidity score.

Compared with low-volume surgeons, high-volume surgeons had fewer in-hospital complications (11% vs 18%, $P<.001$) and their patients had a shorter LOS (3.9 vs 5.5 days, $P<.001$), but costs were comparable (Table 4). Compared with general surgeons, urologists had more complications after adrenalectomy (18% vs 15%, $P=.03$), and their surgical procedures were associated with higher costs ($13 168 vs $11 732, $P=.02$), although LOS was comparable (Table 4). When surgeons were stratified by volume, there was no longer a significant statistical difference in any outcome by specialty (**Table 5**).

ADJUSTED OUTCOMES

All variables that were significant predictors of outcome on bivariate analyses were included in a multivariate regression analysis to identify independent predictors of clinical and economic outcomes after adrenalectomy (**Table 6**). After adjustment, surgeon volume, but not specialty, was an independent predictor of complications (odds ratio = 1.50, $P<.01$) and LOS (1.0-day difference, $P<.001$). Neither was a predictor of costs. Higher hospital volume was associated with shorter LOS (0.8-day difference, $P<.01$) but not with complications or costs.

In addition to low surgeon volume, patient characteristics associated with higher complication rates included older age, lower median household income, bilateral adrenalectomy, open surgical technique, nonroutine admission, greater comorbidity, and location in the West. In addition to low surgeon and hospital volume, independent

predictors of longer LOS included older age, Medicaid insurance, bilateral adrenalectomy, open surgical technique, nonroutine admission, greater comorbidity, location in the Midwest, and more distant year. Independent predictors of higher costs included high median household income, bilateral adrenalectomy, open surgical technique, nonroutine admission, higher comorbidity, and more recent year of surgery.

COMMENT

This is the first population-based study of clinical and economic outcomes after adrenalectomy that encompasses the entire United States and examines the impact of surgeon specialty on patient outcomes after adrenalectomy. After adjustment for all other demographic and clinical characteristics captured in the HCUP-NIS between 1999 and 2005, surgeon volume had a strong association with adrenalectomy complications and LOS; surgeon specialty did not. Neither surgeon volume nor specialty was an independent predictor of costs. High hospital volume was associated with a shorter LOS but did not have a significant effect on complications or costs.

These findings differ somewhat from the previous literature regarding the association of surgeon volume and patient outcomes after adrenalectomy. Using 2002 HCUP-NIS data from New York and Florida, including inpatient (State Inpatient Databases) and outpatient (State Ambulatory Surgery Databases) samples, Stavrakis et al[19] divided surgeons into 6 volume groups. They found no association between surgeon volume and complication rates after adrenal surgery, but they did find a robust association between surgeon volume and mean LOS and total charges. They also found no association between hospital volume and all clinical and economic outcomes. Using mandatory reported hospital discharge data for all inpatient adrenalectomies in Florida from 1998 to 2005, Gallagher et al[20] also found no association between surgeon volume and complication rates and mean LOS. By examining outcomes on a national scale rather than using state-based databases, the present study accounted for the potential regional variation in demographics, insurance infrastructure, and other socioeconomic factors. Varying reimbursement pressures across the country may affect outcomes, such as LOS and costs.

The role of surgical specialty or subspecialty on patient outcomes has been documented in several other types of operations. Thoracic surgeons had lower operative mortality rates after esophageal cancer resection and lung resection than did other surgeons,[27,28] and vascular surgeons had lower in-hospital mortality rates after carotid endarterectomy than did neurosurgeons and general surgeons.[29] Women undergoing surgery for stress urinary incontinence were less likely to undergo a repeated incontinence procedure or prolapsed repair if their condition was initially managed by gynecologists than by urologists.[30] In addition, patients with ovarian cancer had better outcomes when treated by gynecologic oncologists than by general gynecologists or general surgeons,[31] and patients with cutaneous melanoma had significantly better survival when treated by dermatologists than by general or plastic surgeons.[32]

Table 6. Independent Predictors of Outcome After Adrenalectomy

Explanatory Variable[a]	Value[b]	*P* Value
Complications		
Age	1.02	<.001
Median household income		
Medium low	1.41	.01
Medium	1.42	.008
Bilateral procedure	2.54	.004
Open surgical technique	3.30	<.001
Nonroutine admission	1.63	.02
High comorbidity	1.99	.001
Geographic region: West	1.81	.002
Low surgeon volume	1.50	.002
Hospital Length of Stay		
Age	0.04	<.001
Primary payer: Medicaid	0.83	.03
Bilateral procedure	2.49	<.001
Open surgical technique	1.84	<.001
Nonroutine admission	7.48	<.001
Comorbidity		
Medium low	0.92	<.001
Medium	3.14	<.001
High	3.91	<.001
Geographic region: Midwest	0.63	.04
Years: 2003-2005	–0.40	.05
Low hospital volume	0.76	.007
Low surgeon volume	0.98	<.001
Costs, $		
High median household income	1665	.03
Bilateral procedure	6308	.006
Open surgical technique	2980	.001
Nonroutine admission	10 844	<.001
Comorbidity		
Medium low	1784	.03
Medium	6137	<.001
High	10 122	<.001
Years: 2003-2005	1791	<.001

[a] Reference comparisons were low income, private/health maintenance organization insurance, unilateral adrenalectomy, laparoscopy, routine admission, low Charlson Comorbidity Index score, Northeast region, years 1999-2002, high hospital volume, and high surgeon volume.
[b] The values in this column are given as odds ratios for complications and as β-coefficients for hospital length of stay in days and costs in US dollars.

Concerns have been raised that many general surgeons and urologists graduate from residency without adequate operative experience in adrenal surgery. In 1996, Harness et al[21] examined the Resident Statistic Summaries (Report C) of the Residency Review Committee for general surgery from 1986 to 1994. They found that the average number of adrenalectomies performed per general surgery resident was 0.98.[21] An updated analysis of the same data source from 1994 to 2004 showed an increase in the average number of adrenalectomies performed per general surgery resident to 1.46.[22] A 2005 survey of 372 residents and 56 program directors in urology throughout the United States showed that only 52% of urology chief residents had performed a laparoscopic adrenalectomy during their training.[23] Postgraduate training in laparoscopic or endocrine surgery may provide the necessary additional operative experience. It is impossible to measure surgical fellowship training in the HCUP-NIS database.

The analysis of factors associated with improved patient outcomes is particularly salient because adrenalectomy has become more common during the past 20 years. Saunders et al[4] used the HCUP-NIS to analyze adrenalectomy utilization trends and discovered a 43% increase in the total number of adrenalectomies performed between 1988 and 2000. The present study shows that this trend has continued because there was a 26% increase in adrenalectomies from 1999 to 2005. This may be a result of increased utilization and improved resolution of computed tomography leading to the discovery of more incidental adrenal lesions; autopsy and computed tomography have identified incidental adrenal lesions in up to 7% of the general population.[1-3] Another widely cited factor has been laparoscopic adrenalectomy, which is considered to be the new gold standard for adrenal surgery. Several studies[5-8,33-35] comparing laparoscopic with open adrenalectomy for a variety of indications show that the laparoscopic approach leads to decreased complication rates, shorter LOS, and increased patient satisfaction and comfort. The present study confirms that laparoscopic adrenalectomy is associated with lower complication rates, shorter LOS, and lower costs in bivariate and multivariate analyses. The fact that high-volume surgeons used laparoscopy more than twice as often as did low-volume surgeons may have played a large role in the 39% reduction in the complication rate and the 29% reduction in LOS achieved by high-volume surgeons.

Racial disparities in health care have been well documented in the literature. Several studies[36-40] have demonstrated that ethnic minorities have compromised access to preventive care and surgery, thereby increasing the chance of delayed diagnoses and more advanced disease at presentation. The present analysis shows that there is a significant ethnic disparity in access to high-volume adrenal surgeons because African American and Hispanic patients compose 14% and 7%, respectively, of the low-volume surgeon's patients who undergo adrenalectomy but only 9% and 4% of the high-volume surgeon's adrenalectomy practice. Despite this apparent gap in access to high-volume surgeons, African American and Hispanic patients were not found to have significantly worse outcomes; their complication rates, LOS, and costs are comparable with those of white patients. Although racial disparities in adrenalectomy outcomes seem to be nonsignificant, economic disparities still exist. After adjustment for other characteristics, lower median household income was associated with higher complication rates, and Medicaid insurance was associated with longer LOS.

The limitations of this study include those inherent to any large administrative database, although the HCUP-NIS is widely used and has been well validated. Coding errors for diagnoses range from 0.04% to 0.08%.[24] The HCUP-NIS does not identify surgeon specialty training, so we used a proxy for this variable. We ran a comprehensive sensitivity analysis with different combinations and numbers of index urologic procedures per year that would be required to classify a surgeon as a urologist. We found that the fundamental conclusions remain the same, that is, that specialty training is not associated with any clinical or economic outcome. Because there is no specific code for laparoscopic adrenalectomy, we combined the code for laparoscopy of the abdominal regions (*ICD-9-CM* procedure code 54.21) with the code for adrenalectomy to identify laparoscopic adrenalectomy. The proportion of procedures identified as laparoscopic adrenalectomy ranged from 10% to 20%, which seems low compared with estimates in the literature of 60%.[41] Despite this, we believe that the present findings have face validity for several reasons. First, the trend toward increased use of laparoscopy from 1999 to 2005 in these data are consistent with the literature. In addition, high-volume surgeons in high-volume hospitals used laparoscopy more frequently than did low-volume surgeons in low-volume hospitals, and laparoscopy was favorably associated with all 3 outcomes. Another limitation is that long-term outcomes cannot be assessed from the database, and readmissions are not captured. Therefore, the observed complication rates may be underestimated. Other potential modifying factors not captured by the database include number of years in practice, cumulative adrenalectomy experience, and pathologic characteristics of the adrenal lesions.

Surgeon volume, but not specialty, was an independent predictor of complications and LOS after adult adrenalectomy, and neither was a predictor of costs. To optimize outcomes, patients with adrenal disease should be referred to surgeons based on their volume of adrenalectomies and laparoscopic expertise irrespective of their specialty practice.

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Author Contributions: Mr Park had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. *Study concept and design:* Roman and Sosa. *Acquisition of data:* Park and Sosa. *Analysis and interpretation of data:* Park, Roman, and Sosa. *Drafting of manuscript:* Park and Sosa. *Critical revision of manuscript for important intellectual content*: Park, Roman, and Sosa. *Statistical analysis*: Park and Sosa. *Obtained funding:* Park. *Administrative, technical, or material support*: Roman and Sosa. *Supervision*: Roman and Sosa.
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