HHS Public Access

Author manuscript

Surgery. Author manuscript; available in PMC 2019 January 01.

Published in final edited form as:

Surgery. 2018 January ; 163(1): 150–156. doi:10.1016/j.surg.2017.05.024.

Fifteen Years of Adrenalectomies: Impact of Specialty Training and Operative Volume

Brenessa Lindeman, MD MEHP[1], **Daniel A. Hashimoto, MD MS**[2], **Yanik J. Bababekov, MD MPH**[2,3], **Sahael M. Stapleton, MD**[2,3], **David C. Chang, PhD MBA**[2,3], **Richard A. Hodin, MD**[2], and **Roy Phitayakorn, MD MHPE**[2]

[1]Department of Surgery, Brigham and Women's Hospital, Boston, MA

[2]Department of Surgery, Massachusetts General Hospital, Boston, MA

[3]Codman Center for Surgery and Outcomes Research, Massachusetts General Hospital, Boston, MA

Abstract

Background—Previous associations between surgeon volume with adrenalectomy outcomes examined only a sample of procedures. We performed an analysis of all adrenalectomies performed in New York State to assess the effect of surgeon volume and specialty on clinical outcomes.

Methods—Adrenalectomies performed in adults were identified from the New York Statewide Planning and Research Cooperative System (SPARCS) from 2000–2014. Surgeon specialty, volume, and patient demographics were assessed. High volume was defined using a significance threshold at ≥4 adrenalectomies/year. Outcome variables included in-hospital mortality, length-of-stay (LOS), and in-hospital complications.

Results—A total of 6,054 adrenalectomies were included. Median patient age was 56 years; 41.9% were men and 68.3% were white. Urologists (US, n=462) performed 46.8% of adrenalectomies, general surgeons (GS, n=599) performed 35.0%, and endocrine surgeons (ES, n=23) performed 18.1%. Significantly more ES were high-volume compared with US and GS (65.2% vs 10.2% and 6.7%, respectively, p<0.001). High-volume surgeons had significantly lower mortality compared to low-volume surgeons (0.56% vs 1.25%, p=0.004) and a lower rate of complications (10.2% vs 16.4%, p=<0.001). ES were more likely to perform laparoscopic procedures (34.8% vs 22.4% GS and 27.7% US, p<0.001) and had the lowest median hospital LOS (2 days vs 4 days GS and 3 days US, p<0.001). After risk adjustment, low surgeon volume was an independent predictor of inpatient complications (OR = 0.96, p=0.002).

Conclusions—Patients with adrenal disease should be referred to surgeons based on adrenalectomy volume regardless of specialty, but most endocrine surgeons that perform adrenalectomy are high-volume for the procedure.

Corresponding Author: Roy Phitayakorn, MD, MHPE (MEd) FACS, 15 Parkman Street, WACC 460, Boston, MA 02114, (617) 643-7935.

Oral podium presentation at the American Association of Endocrine Surgeons meeting, Orlando, Florida, April 2–4, 2017

Introduction

With more widespread use of computed tomography and improved image resolution, adrenal masses are being diagnosed with increasing frequency in the United States[1]. The rising prevalence of adrenal incidentalomas and development of minimally invasive surgical techniques has resulted in an increased adrenalectomy rate over the past few decades[2]. Although adrenalectomy is associated with an overall low mortality rate (<1%), studies have shown that complication rates can range anywhere from 8–20% and mean hospital lengths of stay (LOS) can stretch to upwards of 8 days[3–4]. These large ranges in complication rate and LOS may in part be due to differences in surgeon volumes. The relationship between surgeon volume and patient outcomes has been examined across a wide variety of procedures including thyroidectomy, pancreaticoduodenectomy, coronary artery bypass grafting, abdominal aortic aneurysm repair, and esophagectomy, and has consistently shown a significant positive association[5–9].

Prior studies of the relationship between surgeon specialty and patient outcomes for adrenalectomy have demonstrated mixed results likely due to the limitations of the patient databases used in these studies[10–12]. The state of New York created the Statewide Planning and Research Cooperative System (SPARCS) database, which allows analysis of outcomes from all patients in the state. More importantly, this database contains specific individual surgeon identifiers. Therefore, we aimed to determine whether further characterization of surgical sub-specialty in addition to surgeon volume influences patient adrenalectomy outcomes.

Methods

Data Source

The New York (NY) Statewide Planning and Research Cooperative System (SPARCS) inpatient database was utilized to capture patients undergoing surgery from 2000–2014. SPARCS is a database for the state of NY that captures all patients and payers and collects information on patients, treatments, and providers for every emergency department admission, inpatient admission, hospital discharge, outpatient visit, and ambulatory surgery appointment.

Patient Population

Adult patients (18 years or greater) undergoing adrenalectomy were the focus of this analysis. Adrenalectomy procedures were selected based on their *International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM)* procedure code, including partial, unilateral, and bilateral adrenalectomy (ICD-9 codes 07.29, 07.22, 07.3). Patients who underwent adrenalectomy in the setting of trauma, liver transplantation, renal malignancy, or as part of a urologic procedure without a diagnosis of primary adrenal disease were excluded. Patient comorbidities were standardized through calculation of the Charlson Comorbidity Index (CCI)[13].

Surgeon Identification and Characteristics

Unique surgeon identifiers in SPARCS (NY state physician license number) were utilized to identify surgeons. Surgeon specialty designations were determined as follows: Urologists (US) were identified as those surgeons who had performed a prostatectomy, cystectomy and cystoscopy in a year for two or more consecutive years. This narrower definition of identifying urologists in a large dataset was utilized after the method used by Park et al[12] misidentified some general surgeons as urologists. All surgeons in this study population that were registered as active or candidate members in the American Association of Endocrine Surgeons (AAES) database[14] were included in the group of endocrine surgeons (ES). All other surgeons who were not urologists or endocrine surgeons were classified as general surgeons (GS).

Independent Variables

Surgeon specialty and surgeon volume were the two primary independent variables in this study, and were treated as categorical variables. High volume surgeons were defined as those who perform 4 adrenalectomies per year or more as described by Park et al[12]. Adrenalectomies were further categorized as unilateral, bilateral, or partial; and technique was classified as minimally invasive (laparoscopic or robotic) or open. While there are no specific codes for laparoscopic adrenalectomy, previously published methodology[12] was utilized to combine the code for laparoscopy or robotic-assisted laparoscopy of the abdomen with the code for adrenalectomy to identify these procedures.

Patient demographic variables included age, race, ethnicity, payer status. Hospital level variables included teaching hospital status (i.e. affiliated with a general surgery residency program) and whether the hospital was in New York City.

Outcome Variables

The primary outcome variable was in-hospital complication. Complications were categorized as postoperative shock, hemorrhagic, infectious/wound, cardiovascular, respiratory/ventilator-associated complications, enteric fistula/leak, adrenal insufficiency, urinary, and other (including retained foreign body) (Appendix A). Secondary outcome variables were length of stay and in-hospital mortality.

Statistical Analysis

Bivariate analysis of the independent variables with the outcomes of interest were performed using the chi-square test for categorical variables and ANOVA for continuous variables. Multivariable logistic regression was utilized for adjusted analysis of complications and mortality. Multivariable linear regression was used for length of stay. Data analysis and management were performed using a statistical software program (Stata version 13.0, StataCorp, College Station, TX). The Institutional Review Board deemed this study exempt from review.

Results

Patient and Provider Characteristics

Between January 1, 2000, and December 31, 2014, 9,385 adult patients were identified in the SPARCS database as having a procedure code for adrenalectomy. One hundred thirty patients were excluded based on the likelihood that adrenalectomy was performed in the setting of trauma. Four patients were excluded on the likelihood that adrenalectomy was performed in the setting of liver transplantation. Patients were also excluded based on the likelihood that the adrenalectomy was performed as part of a primary urological procedure (n=3,197).

A total of 6,054 adrenalectomies were included in the analysis. Overall, 671 (11.1%) of patients experienced at least 1 complication after adrenalectomy, and 51 patients died (0.84%). Median LOS was 3 days (IQR 2–6) with a mean and standard deviation of 5.3 +/− 8.6 days. Hemorrhage accounted for 34.1% of all complications, followed by pulmonary (23.5%), cardiac (18.9%), infectious (11.3%), adrenal insufficiency (10.3%), urinary (9.8%), and wound disruption (1.9%) events (see Appendix A for a list of the ICD-9 codes for each complication).

The majority of patients were female, white, insured by a private insurance carrier, underwent adrenalectomy for a benign neoplasm, had a unilateral adrenalectomy, and had an open operation. Most adrenalectomies were performed at teaching hospitals and in NYC. The distribution of patient demographics and other comorbidities is shown in Table 1.

There were 2,839 adrenalectomies performed by 462 US (46.9%), 1,098 by 23 ES (18.1%), and 2,117 by 599 GS (35.0%) (Table 2). The majority of patients were white and female among all surgeon groups. Endocrine surgeons tended to operate on patients with private insurance, low preoperative comorbidities and with primary endocrine disorders of the adrenal gland significantly more often than general or urologic surgeons. General surgeons were more likely than ES or US to operate on non-white patients, and US were also more likely than GS or ES to operate on patients with high CCI or non-private insurance. Endocrine surgeons also operated more frequently at teaching hospitals, in New York City, and used minimally invasive techniques more often.

Surgeon Volume

Median annual surgeon volume was 1 case (IQR 1–2) with a mean of 2.1 cases, and a range of 1 to 29 cases. Approximately 65.2% of ES were high volume surgeons compared with 10.2% of US and 6.7% of GS ($p<0.001$). Additionally, ES performed a significantly higher median number of adrenalectomies/year (5 [range 1–29, IQR 6–18] ES versus 1 US [range 1–21, IQR 1–5] versus 1 GS [range 1–14, IQR 1–4], $p=<0.001$). Within surgeon subspecialty, there was a greater proportion of high volume ES performing adrenalectomies (97.8%) compared to GS (44.4%) and US (54.9%) ($p<0.001$).

A significantly greater number of high volume surgeons practice in teaching hospitals (77.6% vs. 22.5%, $p<0.001$) or in New York City (64.4% vs. 35.6%, $p<0.001$), irrespective of specialty. Overall, high volume surgeons had a significantly lower complication rate

compared to low volume surgeons (8.76% vs. 14.42%, p<0.001) as well as lower median LOS (high volume: 2 days (IQR 1–5) vs. low volume: 4 days (IQR 2–7), p<0.001). High volume surgeons also had a significantly lower mortality rate of 0.56% compared to low volume surgeons 1.25% (p=0.004).

Unadjusted Outcomes

There were several significant differences in unadjusted clinical outcomes by patient (Table 3) and provider (Table 4) characteristics. Demographic groups with significantly higher complication rates included older individuals, patients with Medicare, malignant diagnosis, open procedure, and higher comorbidity score. Complications were also more common among US and GS compared to ES (p<0.001) and low-volume compared to high-volume surgeons (p<0.001). Of the 51 total deaths, ES had the lowest mortality (n=2, 0.18%) compared to GS (n=17, 0.80%), and US (32, 1.13%) (p=0.014).

Older individuals, patients with Medicare, open procedures, a high CCI score, or bilateral adrenalectomy also had a significantly longer LOS. Complications were more common among urologic and general surgeons and low-volume surgeons, and hospital length of stay was also significantly longer for these groups. There was no significant difference in complication rates or LOS based on teaching hospital status or location.

Adjusted Outcomes

Independent variables with significantly different complication rates on bivariate analyses were included in a multivariable logistic regression to identify independent predictors of complication after adrenalectomy (Table 5). After adjustment, surgeon volume but not specialty, was an independent predictor of complications and mortality. In addition to high surgeon volume, undergoing a minimally invasive operative approach was also associated with significantly lower complication rates. More patient comorbidities, increasing age, and receiving a perioperative transfusion were associated with significantly higher complication rates.

For secondary outcome measures, the same predictors of complications following adrenalectomy also predicted hospital length of stay with the addition of endocrine surgeons being associated with significantly shorter hospital LOS while patients experiencing complications had a significantly longer hospital LOS (Table 6). Neither specialty nor annual volume was predictive of inpatient mortality, but presence of a complication was predictive of mortality (OR 7.38, 95% CI 4.01–13.59, p<0.001).

Discussion

This is the first population-based study of clinical outcomes after adrenalectomy to examine all associated procedures performed within a given state, and the impact of surgeon specialty and duration of practice on patient outcomes after adrenalectomy. The SPARCS database allows for specific surgeon identifiers that more precisely categorize the subset of general surgeons with a subspecialty focus in endocrine surgery, as well as estimating how long each surgeon has been in practice. After adjustments for all other demographic and clinical characteristics captured in the SPARCS database between 2000 and 2014, endocrine

surgeons had significantly shorter hospital LOS, but not complication rates compared to general or urologic surgeons. Surgeon volume was an independent predictor of adrenalectomy complications and hospital LOS in this study. While surgeon specialty was not directly associated with adrenalectomy complications in adjusted analyses, endocrine surgeons were significantly more likely to meet the definition of high-volume compared to surgeons from other specialties. Thus, sub-specialty practice may be a reasonable surrogate marker for high-volume surgeons.

Prior literature about the association between adrenalectomy outcomes and surgeon volume has shown mixed results. Park et al[12] used data from the HCUP-NIS from 1999–2005 to demonstrate that surgeon volume was strongly associated with in-hospital complications and hospital LOS following adrenalectomy, but surgeon specialty (general surgeons and urologists) was not. Using state-level HCUP-NIS data from New York and Florida, Stavrakis et al[10] found no association between surgeon volume and complications after adrenalectomy, but surgeon volume was associated with hospital LOS. These studies are limited by the fact that the HCUP-NIS provides annual data from only a 20% sample of state databases from around the country. Furthermore, while HCUP-NIS provides unique surgeon identifiers, it does not allow for identification of surgeon specialty and specialty must be inferred from procedure codes available within the dataset itself. In another study, Gallagher et al[11] found no association between surgeon volume and complication rates or hospital LOS using Florida hospital discharge data, but was limited by the relatively smaller size and shorter period of time. By examining outcomes from a database that captures information from all adrenalectomies performed, a more complete picture of clinical outcomes can be formed.

The question of surgeon specialty and its relationship to patient outcomes has been studied extensively, both in the context of adrenalectomy as well as in other operations. For both esophagectomy and lung resections, thoracic surgeons have been shown to have lower operative mortality than other surgeons[16–17] and vascular surgeons have lower in-hospital mortality following carotid endarterectomy than either neurosurgeons or general surgeons[18]. For adrenalectomy, general surgeons did have lower complication rates compared to urologists on unadjusted analysis in the study by Park et al[12], but only the relationship between surgeon volume and outcomes remained significant following risk adjustment. No previously reported study has looked specifically at outcomes of adrenalectomy performed by endocrine surgeons in a large database. This study was able to specifically identify endocrine surgeons through membership in AAES, allowing for a detailed analysis of endocrine surgeon outcomes for adrenalectomy. While surgical sub-specialty was not shown to be an independent predictor of complications after adrenalectomy, it was significantly associated with hospital LOS. Data from this study have also shown that surgical sub-specialty is closely tied to surgeon volume in that endocrine surgeons were more likely than general or urologic surgeons to meet the definition of high volume. Additionally, because such surgical sub-specialization is a more recent trend, this study may be underpowered to detect a difference given that the overall proportion of adrenalectomies performed by endocrine surgeons was less than those from general and urologic surgeons, and further study is warranted in this area.

The finding that endocrine surgeons are more likely than surgeons from other disciplines to meet criteria for high-volume adrenalectomy surgeons has broad and important implications. First is the impact on regional hospital specialization and patient referral patterns. Similar to the Centers of Excellence that have been developed in bariatrics and other fields[19], continued expansion of regional health systems may lead to clustering of operative services at a fewer number of healthcare facilities. While some authors have advocated this approach as part of a "volume pledge", other have argued that this may paradoxically limit access to care and create further socioeconomic disparities between those that do and do not have resources to travel for high-volume care[20–22]. Our findings are also informative for shaping the future of surgical training. Adrenalectomy is listed as an "advanced" procedure in the ACS/ABS/APDS SCORE Curriculum[23] and one study of general surgery resident case logs demonstrates an average of only approximately 2 adrenalectomies per resident[24]. Endocrine surgery fellows complete their training with an average of 13 adrenalectomies[25], so efforts to expand the job market for these potentially high-volume adrenal surgeons is one method of ensuring patient access to quality care[26].

Limitations of this study include those inherent to any large administrative database (coding errors, incomplete data capture, etc.), although SPARCS captures all procedures performed within the state of New York and thus represents a very complete picture of what occurs within one geographic area. However, these results may or may not be generalizable to other populations. SPARCS contains surgeon identifiers (state medical license number) that were matched with the membership list of the AAES. It is possible that not all urologists, general surgeons, and endocrine surgeons were accurately matched into their specialty. This study also was not able to adequately capture the true rate of minimally invasive approaches to adrenalectomy performed in New York State over the study period, largely due to the inability to specifically code for retroperitoneoscopic adrenalectomy. While some of these procedures may have been included in the "laparoscopic" procedure category, the majority were coded as open procedures, incongruous with the practice patterns of many of the identified, high-volume adrenal surgeons in this sample. Interestingly, the use of a minimally-invasive approach was associated with a decreased rate of complications on adjusted analysis. This finding demonstrates how significant the reduction in complications is for minimally-invasive techniques. Although likely under-reported, the rate of minimally invasive adrenalectomy is similar to that reported in other studies of adrenalectomy outcomes[27] and is also consistent with the trend toward increasing use of laparoscopy over the study period. In addition, both high-volume surgeons and endocrine surgeons used laparoscopy more frequently than did low-volume surgeons and urologic or general surgeons, and laparoscopy was found to be an independent predictor of lower complication rates. Finally, observed complication rates may be underestimated because this study only examined outcomes in the index hospital admission and complications such as wound infection are commonly diagnosed following discharge.

In conclusion, surgeon volume was an independent predictor of complications and mortality after adrenalectomy. Sub-specialty endocrine surgeons were significantly more likely to meet the definition of high-volume compared to general surgeons or urologists. While patients with adrenal disease should be referred to surgeons based on their annual volume of adrenalectomies, sub-specialty practice may be a reasonable surrogate marker for high-

volume surgeons. This finding has important implications for regional hospital specialization, patient referral patterns, and surgical training.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Financial Support: None

References

1. Song JH, Chaudhry FS, Mayo-Smith WW. The incidental adrenal mass on CT: prevalence of adrenal disease in 1,049 consecutive adrenal masses in patients with no known malignancy. AJR Am J Roentgenol. 2008; 190(5):1163–1168. [PubMed: 18430826]
2. Saunders BD, Wainess RM, Dimick JB, Upchurch GR, Doherty GM, Gauger PG. Trends in utilization of adrenalectomy in the United States: have indications changed? World J Surg. 2004; 28(11):1169–1175. [PubMed: 15490057]
3. Gonzalez R, Smith CD, McClusky DA III, et al. Laparoscopic approach reduces likelihood of perioperative complications in patients undergoing adrenalectomy. Am Surg. 2004; 70(8):668–674. [PubMed: 15328798]
4. Jacobsen NE, Campbell JB, Hobart MG. Laparoscopic versus open adrenalectomy for surgical adrenal disease. Can J Urol. 2003; 10(5):1995–1999. [PubMed: 14633327]
5. Sosa JA, Bowman HM, Tielsch JM, Powe NR, Gordon TA, Udelsman R. The importance of surgeon experience for clinical and economic outcomes from thyroidectomy. Ann Surg. 228(3):320–330. 198.
6. Zelen J, Bilfinger TV, Anagnostopoulos CE. Coronary artery bypass grafting: the relationship of surgical volume, hospital location, and outcome. N Y State J. Med. 1991; 91(7):290–292. [PubMed: 1876313]
7. Birkmeyer JD, Stukel TA, Siewers AE, Goodney PP, Wennberg DE, Lucas FL. Surgeon volume and operative mortality in the United States. N Engl J. Med. 2003; 349(22):2117–2127. [PubMed: 14645640]
8. Dimick JB, Cowan JA Jr, Stanley JC, Henke PK, Pronovost PJ, Upchurch GR Jr. Surgeon specialty and provider volumes are related to outcome of intact abdominal aortic aneurysm repair in the United States. J Vasc Surg. 2003; 38(4):739–744. [PubMed: 14560223]
9. Ho V, Heslin MJ. Effect of hospital volume and experience on in-hospital mortality for pancreaticoduodenectomy. Ann Surg. 2003; 237(4):509–514. [PubMed: 12677147]
10. Stavrakis AI, Ituarte PH, Ko CY, Yeh MW. Surgeon volume as a predictor of outcomes in inpatient and outpatient endocrine surgery. Surgery. 2007; 142(6):887–899. [PubMed: 18063073]
11. Gallagher SF, Wahi M, Haines KL, et al. Trends in adrenalectomy rates, indications, and physician volume: a statewide analysis of 1816 adrenalectomies. Surgery. 2007; 142(6):1011–1021. [PubMed: 18063089]
12. Park HS, Roman SA, Sosa JA. Outcomes from 314 adrenalectomies in the United States: which matters more, surgeon volume or specialty? Arch Surg. 2009; 144(11):1060–1067. [PubMed: 19917944]
13. Romano PS, Roos LL, Jollis JG. Adapting a clinical comorbidity index for use with ICD-9-CM administrative data: differing perspectives. J Clin Epidemiol. 1993; 48:1075–1090.
14. American Association of Endocrine Surgeons. [Accessed January 24, 2017] Membership website. https://www.endocrinesurgery.org/membership/findmember.html
15. Meguid RA, et al. What constitutes a “high-volume” hospital for pancreatic resection? J Amer Coll Surg. 206(4):622:e621–629.

16. Dimick JB, Goodney PP, Orringer MB, Birkmeyer JD. Specialty training and mortality after esophageal cancer resection. Ann Thorac Surg. 2005; 80(1):282–296. [PubMed: 15975382]
17. Goodney PP, Lucas FL, Stukel TA, Birkmeyer JD. Surgeon specialty and operative mortality with lung resection. Ann Surg. 2005; 241(1):179–184. [PubMed: 15622006]
18. Hannan EL, Popp AJ, Feustel P, et al. Association of surgical specialty and processes of care with patient outcomes for carotid endarterectomy. Stroke. 2001; 32(12):2890–2897. [PubMed: 11739992]
19. Zevin B, Aggarwal R, Grantcharov TP. Volume-outcome association in bariatric surgery: a systematic review. Ann Surg. 2012 Jul; 256(1):60–71. [PubMed: 22584692]
20. Finks JF, Osborne NH, Birkmeyer JD. Trends in hospital volume and operative mortality for high-risk surgery. N Engl J. Med. 2011; 364:2128–2137. [PubMed: 21631325]
21. Schwartz DM, Fong ZV, Warshaw AL, Zinner MJ, Chang DC. The Hidden Consequences of the Volume Pledge: “No Patient Left Behind”?.
22. Blanco BA, Kothari AN, Blackwell RH, Brownlee SA, Yau RM, Attisha JP, Ezure Y, Pappas S, Kuo PC, Abood GJ. “Take the Volume Pledge” may result in disparity in access to care. Surgery. 2017 Mar; 161(3):837–845. [PubMed: 27855970]
23. Surgical Council on Resident Education. The SCORE Portal. http://www.surgicalcore.org
24. Bell RH, Biester TW, Tabuenca A, Rhodes RS, Cofer JB, Britt LD, Lewis FR. Operative Experience of Residnets in US General Surgery Programs: A Gap Between Expectation and Experience. Ann Surg. 2009 May; 249(5):719–24. [PubMed: 19387334]
25. Solorzano CC, Sosa JA, Lechner SC, Lew JI, Roman SA. Endocrine surgery: where are we today? A national survey of young endocrine surgeons. Surgery. 2010 Apr; 147(4):536–541. [PubMed: 19939426]
26. Shin JJ, Milas M, Mitchell J, et al. The endocrine surgery job market: A survey of fellows, department chairs, and surgery recruiters. J Surg Educ. 2013; 70:337–383.
27. Lee J, El-Tamer M, Schifftner T, et al. Open and laparoscopic adrenalectomy: analysis of the National Surgical Quality Improvement Program. J Amer Coll Surg. 2008; 206(5):953–961. [PubMed: 18471733]

Table 1

Demographic characteristics of patients undergoing adrenalectomy in New York, 2000–2014

Characteristic	Total (n=6054)
Age, median (IQR)	56 years (46–66 years)
Female sex (%)	3518 (58.11)
Race	
White	4137 (68.33)
African American	819 (13.53)
Asian	246 (4.06)
Other	852 (14.07)
Primary payer	
Private	3478 (57.45)
Medicare	1702 (28.11)
Medicaid	740 (12.22)
Other	102 (1.68)
Principal procedure	
Unilateral	5433 (89.74)
Bilateral	137 (2.26)
Partial	489 (8.08)
Malignant neoplasm	739 (12.21)
Benign neoplasm	3495 (57.7)
Minimally invasive approach	1643 (27.14)
Charlson Comorbidity Index score	
Low (0)	2,684 (44.33)
Medium low (1–2)	1775 (29.32)
Medium (3–4)	459 (7.58)
High (5 or more)	1136 (18.76)
Teaching hospital	3849 (63.58)
New York City	3385 (55.91)

Table 1 shows demographic characteristics of patients undergoing adrenalectomy in New York State between 2000–2014. IQR = inter-quartile ratio

Table 2

Demographic characteristics of patients undergoing adrenalectomy in New York, 2000–2014, by surgeon specialty

Characteristic	Urologic Surgeon (n=2839)	General Surgeon (n=2,117)	Endocrine Surgeon (n=1,098)	*P* Value
Age in years, median (IQR)	56 (46–66)	55 (45–65)	54 (44–64)	<0.001
Female sex, # (%)	1566 (55.2)	1271 (60)	681 (62.02)	<0.001
Race, # (%)				
White	1986 (70)	1376 (65)	775 (70.6)	
African American	397 (14)	311 (14.7)	111 (10.1)	<0.001
Asian	112 (4)	99 (4.7)	35 (3.2)	
Other	344 (12.1)	331 (15.6)	177 (16.1)	
Primary payer, #(%)				
Private	1611 (56.8)	1,178 (55.6)	689 (62.8)	
Medicare	839 (29.6)	583 (27.5)	280 (25.5)	<0.001
Medicaid	320 (11.3)	302 (14.3)	118 (10.8)	
Other	49 (1.73)	42 (2)	11 (1)	
Principal procedure, # (%)				
Unilateral	2543 (89.6)	1900 (89.8)	990 (90.2)	0.861
Bilateral	55 (1.9)	41 (1.9)	41 (3.7)	0.001
Partial	244 (8.6)	178 (8.4)	67 (6.1)	0.029
Diagnosis, # (%)				
Malignant neoplasm	388 (13.7)	245 (11.6)	106 (9.7)	0.001
Benign Neoplasm	1561 (44.7)	1252 (35.8)	682 (19.5)	<0.001
Endocrine Disorder	781 (27.5)	609 (28.8)	401 (36.5)	<0.001
Minimally invasive approach, # (%)	787 (27.72)	474 (22.39)	382 (34.79)	<0.001
Charlson Comorbidity Index score				<0.001
Low (0)	1234 (43.5)	898 (42.4)	552 (50.3)	
Medium low (1–2)	843 (29.7)	623 (29.4)	309 (28.1)	
Medium (3–4)	186 (6.6)	198 (9.4)	75 (6.8)	
High (5 or more)	576 (20.3)	398 (18.8)	162 (14.8)	
Teaching hospital	1615 (56.9)	1179 (55.7)	1055 (96.1)	<0.001
New York City	1366 (48.1)	1101 (52.0)	918 (83.6)	<0.001

Table 2. Comparison of demographic characteristics of patients undergoing adrenalectomy in New York State between 2000–2014, by surgeon specialty. IQR = inter-quartile ratio

Table 3

Unadjusted Outcomes After Adrenalectomy by Patient Characteristics

	Complications		Length of Stay (IQR)	
Characteristic	**% of patients with ≥1 complication**	***P* Value**	**d (IQR)**	***P* Value**
Age		<0.001		0.01
Female sex	11.1	<0.001	3 (2–6)	0.016
Race		0.781		0.051
White	12.8		4 (2–6)	
African American	12.5		3 (2–6)	
Hispanic	10.3		3 (2–6)	
Asian	12.2		3 (2–6)	
Other/Unknown	13.0		3 (2–5)	
Primary payer		<0.001		<0.001
Private	10.7		3 (2–5)	
Medicare	18.2		4 (2–7)	
Medicaid	10.7		3(2–6)	
Self-Pay	7.8		4 (3–8)	
Principal procedure		<0.001		<0.001
Unilateral	12.1		3 (2–5)	
Bilateral	21.2		5 (3–9)	
Partial	17.4		4 (2–7)	
Primary diagnosis		<0.001		0.162
Malignant	18.6		4 (2–7)	
Non-malignant	13.2			
Surgical approach		<0.001		<0.001
Minimally invasive	8.6		2 (1–3)	
Open	14.3		4 (2–7)	
Charlson Comorbidity Index		<0.001		<0.001
Low (0)	6.7		2 (1–4)	
Medium low (1–2)	14.2		3 (2–6)	
Medium (3–4)	23.1		5 (3–8)	
High (5 or more)	20.4		6 (3–9)	

Table 3. Rate of complications and hospital LOS after adrenalectomy in bivariate analysis, by patient characteristics. Age is calculated as a continuous variable. Complication is reported as percent (%) of patients. Length of stay is reported as a median value plus inter-quartile range.

Table 4

Unadjusted Outcomes After Adrenalectomy by Provider Characteristics

	Complications		Length of Stay	
Characteristic	**%**	***P* Value**	**d (IQR)**	***P* Value**
Surgical specialty		0.001		<0.001
Urology	12.1		3 (2–6)	
General	11.8		4 (2–6)	
Endocrine	7.6		2 (1–4)	
Annual volume		<0.001		<0.001
High	10.2		2 (2–5)	
Low	16.4		4 (2–7)	
Hospital teaching status		0.224		<0.001
Teaching	12.3		3 (2–6)	
Non-teaching	13.4		3 (2–6)	
Hospital location		0.24		0.05
New York City	12.3		3 (2–6)	
Other	13.3		3 (2–6)	
Surgeon experience		0.24		0.034
<20 years	12.2		3 (2–5)	
20 or more years	13.2		3 (2–6)	

Table 4. Rate of complications and hospital LOS after adrenalectomy in bivariate analysis, by provider characteristics. LOS is reported as median days plus inter-quartile range (IQR).

Table 5

Independent Predictors of Complication After Adrenalectomy

Characteristic	OR	95% Confidence Interval	*P* Value
Surgeon Specialty (vs GS)			
Endocrine surgeon	0.92	0.65–1.3	0.644
Urologic surgeon	1.13	0.94–1.36	0.198
Age (vs. 18–40 years)			
50–59 years	1.46	1.05–2.03	**0.023**
60–69 years	1.84	1.32–2.58	**<0.001**
70–79 years	2.0	1.33–2.98	**0.001**
80–89 years	2.31	1.34–3.98	**0.003**
Female (vs. male)	0.85	0.73–1.02	0.077
White (vs. non-white)	0.79	0.61–1.02	0.067
Insurer (vs. private)			
Medicare	0.97	0.76–1.25	0.828
Medicaid	1.03	0.77–1.36	0.862
Self-pay	0.82	0.39–1.72	0.590
Year (vs. 2000)			
2001	0.97	0.59–1.58	0.901
2002	0.85	0.52–1.4	0.535
2003	1.0	0.61–1.62	0.991
2004	1.0	0.63–1.64	0.952
2005	0.98	0.6–1.6	0.941
2006	0.99	0.62–1.56	0.954
2007	0.78	0.48–1.26	0.304
2008	1.12	0.71–1.77	0.634
2009	1.14	0.72–1.83	0.574
2010	0.93	0.58–1.5	0.771
2011	1.1	0.69–1.75	0.692
2012	1.09	0.68–1.74	0.717
2013	1.18	0.74–1.89	0.489
2014	0.76	0.46–1.26	0.283
Charlson Comorbidity Index (vs. CCI 0)			
Medium Low (1–2)	1.19	0.95–1.48	0.132
Medium (3–4)	2.29	1.71–3.07	**<0.001**
High (5 or more)	2.67	1.98–3.61	**<0.001**
Perioperative transfusion (vs. none)	2.8	2.15–3.64	**<0.001**
Minimally invasive procedure (vs. open)	0.63	0.50–0.78	**0.020**

Characteristic	OR	95% Confidence Interval	*P* Value
Endocrine disorder diagnosis (vs. non-endocrine)	1.45	1.2–1.76	**<0.001**
Malignant adrenal neoplasm (vs. non-malignant)	0.67	0.48–0.94	**0.013**
Associated nephrectomy (vs. no nephrectomy)	2.41	1.43–4.06	**<0.001**
Surgeon annual volume (per each additional case/year)	0.96	0.94–0.98	**0.002**

Table 5. Multivariate analysis of independent predictors of complications after adrenalectomy, reported as odds ratio (OR) with 95% confidence interval.

Bold p-value represent significant predictors

Table 6

Independent Predictors of Length of Stay After Adrenalectomy

Characteristic	Coeff	95% Confidence Interval	*P* Value
Surgeon Specialty (vs. GS)			
Endocrine Surgeon	−0.9	−1.7, −0.1	**0.028**
Urologic Surgeon	−0.38	−0.84, 0.08	0.102
Age (vs. 18–40 years)			
50–59 years	0.16	−0.54, 0.86	0.658
60–69 years	0.004	−0.67, 0.68	0.99
70–79 years	0.17	−0.57, 0.9	0.657
80–89 years	2.28	0.9, 3.7	**0.002**
>90 years	16.2	9.8, 22.6	**<0.001**
Female sex (vs. male)	−0.5	−0.9, −0.05	**0.030**
White (vs. non-white)	−0.002	−0.63, 0.62	0.996
Insurer (vs private)			
Medicare	0.8	0.14, 1.4	**0.019**
Medicaid	1.5	0.8, 2.1	**<0.001**
Self-pay	3.5	1.9, 5.1	**<0.001**
Year (vs. 2000)			
2001	−0.03	−1.23,1.17	0.962
2002	−1.35	−2.54, −0.16	**0.026**
2003	−1.14	−2.36, 0.08	0.067
2004	−0.79	−2, 0.42	**0.2**
2005	−1.81	−3, −0.62	**0.003**
2006	−1.01	−2.14, 0.13	0.081
2007	−0.1	−2.12, −.13	0.082
2008	−1.0	−2.07, 0.23	0.115
2009	−0.92	−1.67, 0.64	0.385
2010	−0.51	−2.65, −0.37	**0.01**
2011	−0.86	−2.01, −.3	0.147
2012	−1.56	−2.7, −0.4	**0.008**
2013	−1.34	−2.5, −0.16	**0.026**
2014	−1.95	−3.1, −0.77	**0.001**
Charlson Comorbidity Index (vs. CCI 0)			
Medium Low (1–2)	1.35	0.86, 1.84	**<0.001**
Medium (3–4)	3.47	2.66, 4.27	**<0.001**
High (5 or more)	6.37	5.51, 7.24	**<0.001**
Perioperative Transfusion (vs. none)	3.3	2.5, 4.2	**<0.001**

Characteristic	Coeff	95% Confidence Interval	*P* Value
Minimally invasive procedure (vs. open)	−1.4	−1.9, −0.96	**0.001**
Endocrine disorder diagnosis (vs. non-endocrine)	−0.26	−0.71, 0.2	0.269
Malignant adrenal neoplasm (vs. non malignant)	−5.9	−6.9, −4.9	**<0.001**
Associated nephrectomy (vs. no nephrectomy)	5.3	3.5, 7.1	**<0.001**
Complication (vs. no complication)	5.7	5.0, 6.3	**<0.001**
Annual surgeon volume (per each additional case/year)	−0.07	−1.5, −0.6	**<0.001**

Table 6. Multivariate linear regression analysis of independent predictors of hospital LOS after adrenalectomy, reported as β-coefficient with 95% confidence interval.

Bold p-value represent significant predictors.