Published in final edited form as:

Surgery. 2018 October ; 164(4): 766–773. doi:10.1016/j.surg.2018.04.041.

Risk Factors for 30-day Readmission after Adrenalectomy

Anna C. Beck, MD, Paolo Goffredo, MD, Imran Hassan, MD, Sonia L. Sugg, MD, Geeta Lal, MD, James R. Howe, MD, and Ronald J. Weigel, MD, PhD

Department of Surgery, University of Iowa, Iowa City, IA

Abstract

Background—Readmissions represent a substantial burden to the health care system. Risk factors for 30-day readmission after adrenalectomy were examined.

Methods—Patients who underwent adrenalectomy were selected from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database from 2011 to 2015.

Results—Among 4221 patients who underwent adrenalectomy, 216 (5.1%) were readmitted. On multivariate analysis, pre-operative predictive factors associated with readmission were American Society of Anesthesiologists (ASA) classification (OR 1.4, CI 1.1–1.8), disseminated cancer (OR 1.6, CI 1.1–2.5), and adrenal injury (OR 10.9, CI 1.8–68.9). Elective procedures had less readmissions (OR 0.50, CI 0.33–0.76) and procedures with greater RVUs had greater readmission rates (OR 1.01, CI 1.004–1.02). An open adrenalectomy (21% of patients) had a higher rate of readmission compared to a laparoscopic approach (8.0 vs. 4.3%, OR 1.5 CI 1.1–2.0). Post-operative risk factors affecting readmission included reoperations (OR 3.2, CI 1.3–8.0), wound complication (OR 6.6, CI 3.8–11.7), systemic infection (OR 6.5, CI 3.9–10.7), renal complications (OR 7.1, CI 2.6–19.2), venous thrombotic event (VTE) (OR 11.3, CI 5.6–22.6), and discharge to home (OR 0.40 CI 0.22–0.73).

Conclusions—Encouraging the appropriate use of laparoscopic adrenalectomy, preventing VTE and surgical infections, and improving early post-operative follow-up in high-risk patients may decrease readmissions.

INTRODUCTION

Hospital readmissions represent a substantial burden to the health care system with an estimated cost to Medicare of greater \$17 billion.^{1,2} The 30-day readmission rate after hospitalization specifically for a surgical procedure has been as high as 15.6%.² In March 2017, the Medicare Payment Advisory Commission reported an improved rate of preventable hospital readmission to 10.5% in 2015 from 19.6% in 2004; however,

Correspondence: Ronald J. Weigel, MD, PhD, EA Crowell Professor and Chairman, Department of Surgery, University of Iowa, 200 Hawkins Drive, JCI 1509, Iowa City, IA 52242-1086, Telephone: 319-353-7474, FAX: 319-356-8378.

Presented at the Central Surgical Association 2018 Annual Meeting, Columbus, Ohio March 15–17, 2018

Publisher's Disclaimer: This is a PDF file of an unedited manuscript that has been accepted for publication. As a service to our customers we are providing this early version of the manuscript. The manuscript will undergo copyediting, typesetting, and review of the resulting proof before it is published in its final citable form. Please note that during the production process errors may be discovered which could affect the content, and all legal disclaimers that apply to the journal pertain.

preventable readmissions still occur. Increasing efforts have been made to identify the characteristics of surgical patients at risk for readmission and to design systems to prevent readmission.^{2–4}

Adrenalectomy is a relatively uncommon procedure, but the incidence of adrenalectomy is increasing in the United States.⁵ Currently, adrenalectomy is performed for both benign and malignant disease and is approached commonly by both open surgery and laparoscopy or another minimally invasive approach. Outcomes after adrenalectomy have been examined by surgeon specialty⁶, operative approach^{7,8}, and presence of malignancy⁷ with readmission rates reported between 1.5% and 11.3%,^{6,7,9} but, specific risk factors for readmission after adrenalectomy have not been reported previously.

Given the increasing frequency of adrenalectomy, identifying risk factors for readmission in these specific patients may help to guide pre-operative planning and post-operative care. Because adrenalectomy is not a common procedure, the American College of Surgeons' National Surgical Quality Improvement Program Database (ACS-NSQIP) allows for examination of a comprehensive, large, national cohort to overcome the limitations associated with single center studies. Our goal was to use ACS-NSQIP to identify risk factors for readmission after adrenalectomy during the pre-operative, post-operative and intra-operative phases of care, as well as to examine risk of readmission, morbidity, and mortality based on operative approach and type of adrenal disease for which adrenalectomy was performed.

METHODS

Patient identification, classification and collection

All cases with adrenalectomy as the primary procedure were identified in the ACS- NSQIP database from years 2011–2015. Current Procedural Terminology (CPT) codes were used to identify these cases and included 60540 (Adrenalectomy, partial or complete, or exploration of adrenal gland with or without biopsy, transabdominal, lumbar or dorsal), 60545 (...with excision of adjacent retroperitoneal tumor), and 60650 (Laparoscopy, surgical, with adrenalectomy, partial or complete, or exploration of adrenal gland with or without biopsy, transabdominal, lumbar or dorsal). Patients were excluded if 30-day readmission status was unknown. All variables included in the ACS-NSQIP database and common over all five years were examined. Variables with high rates of null values were excluded.

Variables were categorized based on when the variable would be known definitively to a clinician caring for a patient. Pre-operative variables included age, sex, race, body mass index (BMI), American Society of Anesthesiologists (ASA) classification, known co-morbidities, and adrenal disease diagnosis. Known co-morbidities included diabetes, smoking status, chronic obstructive pulmonary disease, dyspnea, ventilator dependence, ascites, congestive heart failure, hypertension on medication, pre-operative acute kidney injury, dialysis use, disseminated cancer, steroid use, >10% weight loss within 6 months of operation, and bleeding disorders. Adrenal disease was identified using the ICD-9 or ICD-10 associated with each of the cases which were categorized by authors A.C.B, G.L, J.R.H. and R.J.W. into the most appropriate category. A substantial portion of patients (29%) had an

ICD-9 or ICD-10 recorded in the NSQIP database that was unspecified adrenal disease or with a disease that did not fit a commonly accepted indication for adrenalectomy (e.g. gastroparesis) and were thus categorized as unspecified/unknown. Although some diagnoses are only confirmed postoperatively, we included the diagnosis as part of the preoperative variables. Operative variables included admission status, operative approach, elective versus non-elective surgery, operative time, total work relative value units (RVUs), and wound classification. Elective surgery is defined by NSQIP as the patient coming from home. Operative time, total work RVUs, blood transfusions, and additional procedures were used as surrogates for operative complexity.

Post-operative variables included hospital duration of stay discharge destination, return to operating room, blood transfusion, wound complications, systemic infectious complications, and other systemic complications. Wound complications consisted of superficial surgical site infections (SSI), deep SSI, organ/space SSI, and wound disruptions. Systemic infectious complications included pneumonia, urinary tract infection, sepsis, and septic shock. Other systemic complications were defined as cardiopulmonary complications, including unplanned intubation, ventilatory support >48h, cardiac arrest, or myocardial infarction; progressive renal insufficiency, or acute renal failure, venous thrombotic event, including pulmonary embolus or deep venous thrombosis, and cerebrovascular accidents.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics (Armonk, NY). Continuous variables were represented as mean $\pm$ standard deviation (SD) and categorical variables as median and interquartile range (IQR). Unpaired Student's t-test and Pearson's correlation were used to examine continuous variables. The Mann-Whitney test, Spearman correlations, and Kruskal-Wallis test were used to examine categorical variables. Multivariate logistic regression was used to generate odds ratios and identify cofounders and was run separately for preoperative, intraoperative, and post-operative variables. Variables with 0.2 p-value on univariate analysis were included in multivariate analysis. Significance was defined as a p value less than 0.05.

RESULTS

Over this time period, 659, 243, and 3,387 patients were identified with CPT codes 60540, 60545 and 60650, respectively. Readmission status was unknown for 68 patients, and these were excluded from further analysis. There was a trend for an increase in the annual number of patients who underwent adrenalectomy as a primary procedure reported in the database from 2011 to 2015 (Figure 1); however, the number of cases per institution decreased. The median time from operation to discharge was 2 days (IQR 1–4). There were 216 (5.1%) patients readmitted within 30 days of adrenalectomy, which occurred at a median of 14 (IQR 7– 21) days after discharge.

Pre-operative variables associated with readmission

On univariate analysis, ASA classification, diabetes, dialysis, disseminated cancer, bleeding disorders, primary adrenal malignancy, and injury/hemorrhage were all associated with

increased rates of readmission (Table 1). Although a diagnosis of adrenal injury or hemorrhage was rare, only occurring in 0.1% of patients, this diagnosis was associated with a readmission rate of 40%, which was the greatest rate for any of the variables. Patients with adrenal injury or hemorrhage were more likely to undergo non-elective operations compared to all patients undergoing adrenalectomy (80% vs. 7.2%, $p<0.001$). Additionally, these patients were more likely to have open procedures (60% vs. 21%, $p=0.032$) and had greater rates of blood transfusion (80% vs. 7.2%, $p<0.001$). All cases of adrenal injury or hemorrhage ($n=5$) were coded with adrenalectomy as the primary procedure and additionally used the ICD-9 codes 868.04, 868.01, 568.81, 459, and 998.12. Three cases had additional procedures performed. Adrenalectomy for a benign neoplasm was the only variable associated with a decreased risk of readmission.

Intraoperative variables associated with readmission

A number of intraoperative variables were analyzed for association with readmission rates (Table 2). A laparoscopic approach was used in 79% of patients, and the risk of readmission was less compared to those who underwent open adrenalectomy (4.3 vs. 8.0%, $p<0.001$). Patients who required readmission had a greater mean operative time compared to patients not readmitted (171 ± 94 vs. 150 ± 81 minutes, $p<0.001$). Interestingly, wound classification was not associated with readmission rates; however, 98.7% of cases were clean or clean/contaminated. Total work RVUs were used as an indication for the complexity of the operation and was associated with an increased rate of readmission ($p<0.001$). Additional procedures were performed in 736 (17.4%) patients and were associated with greater rates of readmission ($p<0.001$). The most common procedures included cholecystectomy (92, 12.5%), lysis of adhesions (80, 10.8%), liver biopsy or resection (54, 7.3%), hernia repair (36, 4.9%), and partial or complete nephrectomy (32, 4.3%).

An elective indication for adrenalectomy was associated with a decrease in readmission ($p<0.001$); 6.9% of procedures were non-elective, and 0.3% were unknown. Non-elective cases occurred in patients with adrenal diseases as follows: primary malignancy ($n=30$), non-adrenal primary malignancy (17), benign neoplasm (122), Cushing's disease/syndrome (13), pheochromocytoma (5), carcinoid (unknown whether a primary carcinoid of the adrenal or a metastasis)(1), hyperaldosteronism (7), gluco or mineralocorticoid deficiency (2), adrenal injury or hemorrhage (4), and unknown/unspecified (105).

Post-operative variables associated with readmission

All post-operative complications except for wound dehiscence were associated with a greater rate of 30-day readmission on univariate analysis (Table 3). Infectious complications were the most common variable associated with readmissions. Greater durations of stay were associated with greater readmission rates ($p<0.001$). Discharge destination was associated with readmission with a greater incidence of patients being readmitted who were discharged to a skilled nursing facility and lesser readmission rates for those discharged home ($p<0.001$). Seventeen (0.4%) deaths occurred, and 4 within the population of 216 patients (1.9%) readmitted ($p=0.001$).

Association of Type of Adrenal Disease and Outcome

Patients undergoing adrenalectomy with primary adrenal malignancy as the primary diagnosis had a readmission rate of 8.2%, which was statistically different compared to all patients undergoing adrenalectomy (Table 4). Patients with any malignancy were more likely to have an ASA classification ≥ 3 pre-operatively (76% vs. 67.9%, $p<0.001$) and greater rates of disseminated cancer (44.6% vs. 1.9%, $p<0.001$) than patients overall. Compared to all patients undergoing adrenalectomy, patients undergoing adrenalectomy for malignancy were more likely to undergo open adrenalectomy (44.2% vs. 21.0%, $p<0.001$) and had greater mean operative times (181 ± 98 vs. 151 ± 82 minutes, $p<0.001$). Post-operatively, wound complications (4.0% vs. 1.9%, $p<0.001$) and blood transfusions (18.5% vs. 7.2%, $p<0.001$) were more common in patients with malignancy.

Patients with Cushing's disease/syndrome as the primary diagnosis had a greater ASA classification (≥ 3) pre-operatively (88.8% vs. 67.9%, $p=0.011$). Operative time was greater in Cushing's disease/syndrome, and these patients were more likely to have undergone laparoscopic surgery (Table 4). The readmission rate (5.6% vs. 5.1%, $p=0.808$) was similar in Cushing's disease/syndrome compared to all patients undergoing adrenalectomy; however, mortality rate (2.1% vs. 0.4%, $p<0.001$) was increased. Additionally, other adrenal diseases were associated with specific post-operative morbidities. Those with pheochromocytomas had greater rates of systemic infections (9.6% vs. 3.2%, $p=0.007$) and renal insufficiency or failure (3.8% vs. 0.6%, $p=0.004$), with a trend for greater rates of readmission (7.7%) and mortality (1.9%, $p=0.09$) but not readmission (7.7%). In the seven carcinoid patients, one developed a DVT and one required readmission; no comparisons were possible due to the limited numbers of carcinoid patients. Patients with benign, non-functional neoplasms, hyperaldosteronism, and mineralocorticoid or glucocorticoid deficiency (e.g. congenital adrenal hyperplasia) did not have increased an risk of post-operative morbidity or mortality.

Multivariate Analysis of Variables Affecting Readmission

Pre-operative variables on multivariate analysis, including a greater ASA classification (OR 1.436, 95% CI 1.120–1.842), disseminated cancer (OR 1.636, 95% CI 1.061–2.524), and a diagnosis of adrenal injury or hemorrhage (OR 10.990, 95% CI 1.752–68.920) had greater rates of 30-day readmission (Table 5). Patient age (OR 0.99, 95% CI 0.989–1.010), diabetes (OR 1.356, 95% CI 0.975–1.878), dialysis (OR 2.348, 95% CI 0.737–7.483), dyspnea (OR 1.202, 95% CI 0.781–1.850), weight loss (OR 1.743, 95% CI 0.822–3.694), and bleeding disorder (OR 1.746, 95% CI 0.904–3.372) did not remain statistically significant. The diagnosis of a benign neoplasm was associated with a lesser rate of readmission on univariate analysis, although it did not remain statistically significant on multivariate analysis (OR 0.769, 95% CI 0.566–1.045). Primary adrenal malignancy had a greater rate of readmission on univariate analysis but did not remain statistically significant on multivariate analysis (OR 1.389, 95% CI 0.812–2.376).

On multivariate analysis, elective procedures had lesser risk (OR 0.505, 95% CI 0.334–0.762) and more complex procedures associated with greater total RVUs had greater rates of readmission (OR 1.014, 95% CI 1.004–1.024). The operative approach (open vs.

laparoscopic) also remained statistically significant on multivariate analysis (OR 1.464, 95% CI 1.051–2.040) (Table 5), but, the performance of other procedures at the time of adrenalectomy (OR 1.027, 95% CI 0.670–1.579) and operative time (OR 1.001, 95% CI 1.000–1.003) did not remain statistically significant.

On multivariate analysis, post-operative variables, including return to the operating room (OR 3.265, 95% CI 1.329–8.017), wound complication (OR 6.635, 95% CI 3.754–11.727), systemic infection (OR 6.455, 95% CI 3.891–10.711), renal insufficiency or failure (OR 7.104, 95% CI 2.625–19.226), and venous thrombotic event (OR 11.252, 95% CI 5.612–22.559) remained statistically significant (Table 5). Discharge to home remained statistically significant on multivariate analysis for lesser rates of readmission (OR 0.401, 95% CI 0.219–0.734). Cardiopulmonary complication (OR 0.804, 95% CI 0.315–2.051), hospital duration of stay (OR 1.127, 95% CI 0.796–1.596), blood transfusion (OR 1.319, 95% CI 0.809–2.149), and cerebrovascular accident (OR 1.281, 95% CI 0.162–10.116) were not statistically significant on multivariate analysis.

DISCUSSION

Readmission rates for surgical patients have become an important quality metric and also impact incentive payments through the Hospital Readmission and Reduction Program (HRRP).^{10, 11} The 30-day hospital readmission rate for general surgical procedures is approximately 11–15%, and the rates for readmission have been decreasing over the past decade.^{2, 4, 10} The focus on hospital readmission has been driven by a desire to decrease the costs of health care.^{11, 12} Although decreasing readmissions through improved discharge planning appears to improve patient satisfaction, the effect on decreasing costs is less clear.¹³ In fact, readmission rates after surgery may often relate to complex social issues or medical conditions that may not be related to the index reason for hospital admission.^{12, 14} Nevertheless, the current retrospective analysis was undertaken to identify specific variables associated with readmission after adrenalectomy with the intent of identifying potential means to decrease readmission rates for patients undergoing adrenal surgery. Many of the variables identified in the current study that were associated with increased readmission were patient variables that were not likely to be altered by the surgical treatment. Focusing on those parameters that might be altered by pre-operative preparation, patient selection, operative approach, or post-operative care may decrease readmissions after adrenalectomy.

Previous studies examining adrenalectomy have reported a substantial variation in overall readmission rates between 2% and 10%.^{6, 7, 9} These reports are consistent with the current study with an overall readmission rate of 5.1%. Studies attempting to define risk factors for readmission have focused on a comparison of open adrenalectomy versus laparoscopic or other minimally invasive approaches. Although open adrenalectomy has been associated with a greater duration of stay, most studies have failed to identify a significant difference in readmission rates for open compared to minimally invasive adrenalectomy.^{7, 8, 15} In the current study, we identified an increase in readmission rate for open adrenalectomy, which remained statistically significant and clinically important on multivariate analysis. A previous study reported a trend for increased readmission for open adrenalectomy compared to a minimally invasive approach, and the failure to identify a difference may have been due

to the lower number of patients in the previous report.¹⁵ Intraoperative adverse events have been shown to increase the risk of readmission in patients undergoing abdominal operations.¹⁶ Avoidance of intraoperative complications may account for the reported association between decreased complications and lesser rates of readmission after adrenalectomy for high-volume surgeons.^{9, 17} In contrast, studies of emergent general surgical procedures failed to identify a difference in readmission rates for low-volume vs. high-volume surgeons, even when considering complex operations.¹⁸ Because operative experience in adrenalectomy is known to play an important role in operative time and blood loss,¹⁹ our finding that increased readmission rates were associated with greater operative times and increased transfusion requirements could be partially related to low-volume surgeons, in addition to other patient-related factors. The decrease in number of adrenalectomies performed per institution may be a worrisome trend that could increase readmission rates.

Systemic infections and SSI were the most important factors influencing readmissions. Infectious complications have been reported previously as one of the most important causes for readmissions on the general surgery service.^{3, 4, 14, 20} The current study is one of the few studies to report the incidence of infections after adrenalectomy, and these data may increase our ability to prevent infectious complications. We identified an increase in readmission rates for all complications related to SSI. Recent guidelines have been revised for the prevention of SSI, and recommendations for clean and clean/contaminated cases applied to adrenalectomy are likely to result in decreased SSI rates and decreased readmissions.²¹ Previous studies reported that antimicrobial prophylaxis had no effect on SSI rates in clean category, minimally invasive adrenalectomy.²² Additionally, certain patient-related variables, such as obesity, older age, and diabetes, influence postoperative infectious complications after adrenalectomy.^{17, 23, 24} Although these patient-related variables may not be altered by surgical care, their presence may in some cases influence patient selection and/or pre-operative preparation.

As reported previously, adrenalectomy for malignant tumors was associated with a greater rate of postoperative complications, including deep vein thrombosis and potential pulmonary embolism²⁵, which may be prevented by following appropriate guidelines for venous thromboembolism prophylaxis. In the current study, venous thrombotic events were nearly 12- times more likely in the patients readmitted and could potentially be avoided. Despite this, adrenalectomy for metastatic disease appeared to have acceptable rates of readmission and mortality. Additionally, the greatest number of readmissions occurred in patients with a benign neoplasm, because it was the most common adrenal disease even though overall rate of readmission was low (4.2%). This observation emphasizes the multi-factorial nature of readmissions and the importance of identifying different types of risk factors that occur during all phases of care.

Specific details regarding the clinical scenarios and operative procedures are not tracked in NSQIP. This limited our ability to assess all specific details regarding each case that may have influenced readmission. Specifically, we were not able to assess if blood was transfused during a procedure or postoperatively, why a case was non-elective, and what exact scenarios led to adrenalectomy with uncommon indications, such as carcinoid and adrenal injury or hemorrhage.

In conclusion, unplanned readmission after adrenalectomy is related to specific comorbidities, operative parameters, and post-operative complications. Additionally, the adrenal disease for which adrenalectomy is performed correlated with different risks of readmission, and the types of post-operative complications varied with adrenal pathology. The data suggest readmissions after adrenalectomy may be decreased by developing clinical guidelines for VTE prophylaxis and SSI prevention specific for adrenalectomy, expanding the use of the laparoscopic approach, and identifying patients with non-modifiable risk factors for readmission. Identifying patients with a high risk of readmission may allow allocation of resources to decrease both readmissions and health care costs.

ACKNOWLEDGEMENTS

We would like to thank Mary Belding-Schmitt for providing access to the NSQIP database. A.C.B. was supported by the NIH grant T32CA148062.

Financial Support: A.C.B. was supported by the NIH grant T32CA148062.

Abbreviations:

ACS-NSQIP	American College of Surgeons National Surgical Quality Improvement Program
CPT	Current Procedural Terminology
RVU	Relative Value Units
OR	Odds Ratio
CI	Confidence interval
SD	Standard deviation
IQR	interquartile range
ASA	American Society of Anesthesiologists
SSI	surgical site infections
LOS	length of stay

REFERENCES

1. Friedman B, Basu J. The rate and cost of hospital readmissions for preventable conditions. *Med Care Res Rev* 2004;61:225–40. [PubMed: 15155053]
2. Jencks SF, Williams MV, Coleman EA. Rehospitalizations among patients in the Medicare fee-for-service program. *N Engl J Med*. 2009;360:1418–28. [PubMed: 19339721]
3. Lovecchio F, Farmer R, Souza J, Khavanin N, Dumanian GA, Kim JY. Risk factors for 30-day readmission in patients undergoing ventral hernia repair. *Surgery*. 2014;155:702–10. [PubMed: 24612622]
4. Kassir MT, Owen RM, Perez SD, Leeds I, Cox JC, Schnier K, et al. Risk factors for 30-day hospital readmission among general surgery patients. *J Am Coll Surg*. 2012;215:322–30. [PubMed: 22726893]

5. Murphy MM, Witkowski ER, Ng SC, McDade TP, Hill JS, Larkin AC, et al. Trends in adrenalectomy: a recent national review. *Surg Endosc*. 2010;24:2518–26. [PubMed: 20336320]
6. Sood A, Majumder K, Kachroo N, Sammon JD, Abdollah F, Schmid M, et al. Adverse Event Rates, Timing of Complications, and the Impact of Specialty on Outcomes Following Adrenal Surgery: An Analysis of 30-Day Outcome Data From the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP). *Urology*. 2016;90:62–8. [PubMed: 26743396]
7. Shaligram A, Unniravi J, Meyer A, Reynoso JF, Pallati P, Oleynikov D. Perioperative outcomes after adrenalectomy for malignant neoplasm in laparoscopic era: a multicenter retrospective study. *Surg Laparosc Endosc Percutan Tech*. 2012;22:523–5. [PubMed: 23238380]
8. Goffredo P, Adam MA, Thomas SM, Scheri RP, Sosa JA, Roman SA. Patterns of Use and Short-Term Outcomes of Minimally Invasive Surgery for Malignant Pheochromocytoma: A Population-Level Study. *World J Surg*. 2015;39:1966–73. [PubMed: 25821949]
9. Palazzo F, Dickinson A, Phillips B, Sahdev A, Bliss R, Rasheed A, et al. Adrenal surgery in England: better outcomes in high-volume practices. *Clin Endocrinol (Oxf)*. 2016;85:17–20. [PubMed: 26776382]
10. Mehtsun WT, Papanicolas I, Zheng J, Orav EJ, Lillemoe KD, Jha AK. National Trends in Readmission Following Inpatient Surgery in the Hospital Readmissions Reduction Program Era. *Ann Surg*. 2017.
11. Burgess JF, Hockenberry JM. Can all cause readmission policy improve quality or lower expenditures? A historical perspective on current initiatives. *Health Econ Policy Law*. 2014;9:193–213. [PubMed: 23987089]
12. Williams MV. A requirement to reduce readmissions: take care of the patient, not just the disease. *JAMA*. 2013;309:394–6. [PubMed: 23340642]
13. Goncalves-Bradley DC, Lannin NA, Clemson LM, Cameron ID, Shepperd S. Discharge planning from hospital. *Cochrane Database Syst Rev* 2016:CD000313. [PubMed: 26816297]
14. McIntyre LK, Arbabi S, Robinson EF, Maier RV. Analysis of Risk Factors for Patient Readmission 30 Days Following Discharge From General Surgery. *JAMA Surg*. 2016;151:855–61. [PubMed: 27303913]
15. Maurice MJ, Bream MJ, Kim SP, Abouassaly R. Surgical quality of minimally invasive adrenalectomy for adrenocortical carcinoma: a contemporary analysis using the National Cancer Database. *BJU Int*. 2017;119:436–43. [PubMed: 27488744]
16. Nandan AR, Bohnen JD, Chang DC, Yeh DD, Lee J, Velmahos GC, et al. The impact of major intraoperative adverse events on hospital readmissions. *Am J Surg*. 2017;213:10–7. [PubMed: 27435433]
17. Kazaure HS, Roman SA, Sosa JA. Adrenalectomy in older Americans has increased morbidity and mortality: an analysis of 6,416 patients. *Ann Surg Oncol*. 2011;18:2714–21. [PubMed: 21544656]
18. Mehta A, Efron DT, Canner JK, Dultz L, Xu T, Jones C, et al. Effect of Surgeon and Hospital Volume on Emergency General Surgery Outcomes. *J Am Coll Surg*. 2017;225:666–75 e2. [PubMed: 28838870]
19. Conzo G, Gambardella C, Candela G, Sanguinetti A, Polistena A, Clarizia G, et al. Single center experience with laparoscopic adrenalectomy on a large clinical series. *BMC Surg*. 2018;18:2. [PubMed: 29325527]
20. Havens JM, Olufajo OA, Cooper ZR, Haider AH, Shah AA, Salim A. Defining Rates and Risk Factors for Readmissions Following Emergency General Surgery. *JAMA Surg*. 2016;151:330–6. [PubMed: 26559368]
21. Berrios-Torres SI, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, et al. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. *JAMA Surg*. 2017;152:784–91. [PubMed: 28467526]
22. Kijima T, Masuda H, Yoshida S, Tatokoro M, Yokoyama M, Numao N, et al. Antimicrobial prophylaxis is not necessary in clean category minimally invasive surgery for renal and adrenal tumors: a prospective study of 373 consecutive patients. *Urology*. 2012;80:570–5. [PubMed: 22743261]
23. Kazaure HS, Roman SA, Sosa JA. Obesity is a predictor of morbidity in 1,629 patients who underwent adrenalectomy. *World J Surg* 2011;35:1287–95. [PubMed: 21455782]

24. Turrentine FE, Stukenborg GJ, Hanks JB, Smith PW. Elective laparoscopic adrenalectomy outcomes in 1099 ACS NSQIP patients: identifying candidates for early discharge. *Am Surg.* 2015;81:507–14. [PubMed: 25975337]
25. Marcadis AR, Rubio GA, Khan ZF, Farra JC, Lew JI. High perioperative morbidity and mortality in patients with malignant nonfunctional adrenal tumors. *J Surg Res.* 2017;219:259–65. [PubMed: 29078892]

Author Manuscript

Author Manuscript

Author Manuscript

Author Manuscript

Figure 1. Rate of Adrenalectomy by Year.

Adrenalectomies reported in the NSQIP database over the study period increased from 633 (15%) procedures in 2011, 819 (19.4%) in 2012, 812 (19.2%) in 2013, 921 (21.8%) in 2014, and 1036 (24.5%) in 2015, ($p=0.06$). Additionally, there was a trend for a decrease in the number of adrenalectomies performed per institution ($p=0.06$).

Table 1.**Pre-operative Univariate Variables and Readmission Rates**

	All patients n= 4221	Readmission n=216	No readmission n=4005	p-value
<i>Demographic Variables</i>				
Age (years, mean $\pm$ SD)	54 $\pm$ 14	55 $\pm$ 14	54 $\pm$ 14	0.119
Female sex (n, %)	2479, 58.7%	129, 59.7%	2350, 58.7%	0.761
Race (n, %)				0.626
Asian	167, 4.0%	5, 2.3%	162, 4.0%	
Black	566, 13.4%	34, 15.7%	532, 13.3%	
White	2977, 70.5%	154, 71.3%	2823, 70.5%	
Other or Unknown	511, 12.1%	23, 10.6%	488, 12.2%	
Body Mass Index (mean $\pm$ SD)	30.7 $\pm$ 7.5	31.4 $\pm$ 8.8	30.7 $\pm$ 7.4	0.204
ASA classification (n, %)				<0.001
Unknown	5	0	5	
1 - No disturbance	58	0,	58	
2 - Mild disturbance	1289, 30.5%	40, 18.5%	1249, 31.2%	
3- Severe disturbance	2571, 60.9%	156, 72.2%	2415, 60.3%	
4 - Life threat	296, 7.0%	20, 9.3%	276, 6.9%	
5 – Moribund	2	0	2	
<i>Pre-operative Co-morbidities (n, %)</i>				
Diabetes	823, 19.5%	57, 26.4%	766, 19.1%	0.009
Smoking	967, 22.9%	47, 21.8%	920, 23.0%	0.680
Chronic obstructive pulmonary disease	229, 5.4%	13, 6.0%	216, 5.4%	0.693
Dyspnea on exertion or at rest	379, 9.0%	27, 12.5%	352, 8.8%	0.063
Ventilator dependent	4	0	4	0.642
Ascites	3,	0	3	0.687
Congestive heart failure	25	2	23	0.512
Hypertension on medication	2912, 69.0%	155, 71.8%	2757, 68.8%	0.366
Pre-operative acute kidney injury	6	1	5	0.199
Dialysis, pre-operative	23,	4	19	0.007
Disseminated cancer	336, 8.0%	30, 13.9%	306, 7.6%	0.001
Steroid use	133, 3.2%	10, 4.6%	123, 3.1%	0.202
>10% weight loss within 6 months	83	8, 3.7%	75	0.059
Bleeding disorder	103, 2.4%	11, 5.1%	92, 2.3%	0.009
<i>Adrenal Disease</i>				
Primary Adrenal Malignancy	208, 4.9%	17, 7.9%	191, 4.8%	0.040
Non-adrenal primary Malignancy	364, 8.6%	21, 9.7%	343, 8.5%	0.555
Benign Neoplasm	1968, 46.6%	83, 38.4%	1885, 47.1%	0.013
Cushing's disease/syndrome	144, 3.4%	8, 3.7%	136, 3.4%	0.808
Pheochromocytoma	52	4	48,	0.397
Carcinoid (benign or malignant)	7,	1	6	0.271

	All patients n= 4221	Readmission n=216	No readmission n=4005	p-value
Hyperaldosteronism, primary and secondary	229, 5.4%	9, 4.2%	220, 5.5%	0.402
Glucocorticoid or mineralocorticoid deficiency *	19	0	19	0.310
Injury or Hemorrhage	5	2	3	<0.001
Unspecified/Unknown	1225, 29.0%	71, 32.9%	1154, 28.8%	0.201

* Glucocorticoid or mineralocorticoid deficiency includes adrenogenital disorders.

Table 2.**Operative Univariate Variables and Readmission Rates**

	All patients n= 4221	Readmission n=216	No readmission n=4005	p-value
Admission status (n, %)				0.214
Inpatient	3610, 85.5%	191, 88.4%	3419, 85.4%	
Outpatient	611, 14.5%	25, 11.6%	586, 14.5%	<0.001
Operative approach (n, %)				
Laparoscopic adrenalectomy	3334, 79.0%	145, 67.1%	3189, 79.6%	
Open adrenalectomy	887, 21.0%	71, 32.9%	816, 20.4%	
Elective surgery (n, %)	3918, 92.8%	186, 86.1%	3732, 93.2%	<0.001
Operative time, min (mean $\pm$ SD)	151 $\pm$ 82	171 $\pm$ 94	150 $\pm$ 81	<0.001
Total work RVUs* (mean$\pm$SD)	24 $\pm$ 10	28 $\pm$ 17	24 $\pm$ 10	<0.001
Wound classification (n, %)				0.151
Clean	3425, 81.1%	167, 77.3%	3258, 81.3%	
Clean/contaminated	745, 17.6%	47, 21.8%	698, 17.4%	
Contaminated	48	1	47	
Dirty/Infected	3	1	2	

* RVUs- relative value units

Table 3.

Post-operative variables and Readmission Rates

	All patients n= 4221	Readmission n=216	No readmission n=4005	p-value
Hospital duration of stay, days (median, interquartile range)	2, 1–4	3, 2–6	2, 1–4	<0.001
Return to operating room (n, %)	47	15, 6.9%	32	<0.001
Required blood transfusion (n, %)	304, 7.2%	33, 15.4%	271, 6.7%	<0.001
Wound complication	79	26, 12.0%	53	<0.001
Superficial SSI* (n, %)	49	10, 4.6%	39	<0.001
Deep incisional SSI (n, %)	7	3	4,	<0.001
Organ space SSI (n, %)	20	12, 5.6%	8,	<0.001
Wound dehiscence (n, %)	5	1	4	0.131
Systemic Infectious complication	133, 3.2%	42, 19.4%	91	<0.001
Pneumonia (n, %)	62	15, 6.9%	47,	<0.001
Urinary tract infection (n, %)	56	18, 8.3%	38	<0.001
Sepsis (n, %)	31	12, 5.6%	19	<0.001
Septic Shock (n, %)	16	5, 2.4%	11,	<0.001
Systemic complication				
Cardiopulmonary complication [†] (n, %)	76	16, 7.4%	60	<0.001
Venous thrombotic event [‡] (n, %)	46	18, 8.3%	28	<0.001
Renal insufficiency or failure (n, %)	27	11, 5.1%	16	<0.001
Cerebrovascular complication (n, %)	9	2	7	0.020
Discharge Destination				0.006
Home or facility that was home (n,%)	4098, 97.1%	204, 92.3%	3894, 97.2%	
Skilled Care (n,%)	64	10, 4.5%	54	
Rehab (n, %)	28	1,	27	
Separate Acute Care (n, %)	10	1	9	
Expired prior to discharge (n,%)	11	0	11	
Unknown (n,%)	10	0,	10	
30-day Mortality	17	4	13	0.001

* SSI - surgical site infection;

[†] Cardiopulmonary complication includes re-intubation, failure to wean ventilator in < 48 h, cardiac arrest, and myocardial infarction;

[‡] Venous thrombotic event includes pulmonary embolus and deep venous thrombosis.

Table 4.

Univariate Association of Adrenal disease, operative complexity and readmission

Adrenal Disease	Total	Readmission		Operative Time (min)		Open Adrenalectomy		30-day Mortality	
	N, %	N, %	p-value	mean±SD	p-value	N, %	p-value	N,%	p-value
All patients	4221, 100%	216, 5.1%		151±82		887, 21.0%		17	
Primary Adrenal Malignancy	208, 4.9%	17, 8.2%	0.040	1822±92	<0.001	109, 52.4%	<0.001	1	0.855
Non-adrenal Primary Malignancy	364, 8.6%	21, 5.8%	0.555	181±101	<0.001	144, 39.5%	<0.001	1	0.687
Benign Neoplasm	1968, 46.6%	83, 4.2%	0.013	139±73	<0.001	286, 14.5%	<0.001	4	0.056
Cushing's disease/syndrome	144, 3.4%	8, 5.6%	0.808	185±108	<0.001	17, 11.8%	0.006	3, 2.1%	0.001
Pheochromocytoma	52	4, 8%	0.397	163±76	0.278	11, 21.2%	0.980	1	0.082
Carcinoid (benign or malignant)	7		0.271	214±113	0.041	5	0.001	0	0.866
Hyperaldosteronism, primary and secondary	229, 5.4%	9, 3.9%	0.402	123±62	<0.001	5, 2.2%	<0.001	0	0.323
Glucocorticoid or mineralocorticoid deficiency	19,	0	0.310	146±62	0.783	6, 32%	0.257	0	0.781
Injury or Hemorrhage	5	2	<0.001	193±124	0.251	3	0.032	0	0.887
Unspecified/Unknown	1225, 29.0%	71, 5.8%	0.201	155±81	0.015	301, 24.6%	<0.001	7	0.269

Table 5.

Statistically significant variables on Multivariate Analyses by Phase of Care for Readmission after Adrenalectomy

	Odds Ratio	95% CI
<i>Pre-operative Variables</i>		
ASA * Classification	1.436	1.120–1.842
Disseminated Cancer	1.636	1.061–2.524
Adrenal Injury or Hemorrhage	10.990	1.752–68.920
<i>Operative Variables</i>		
Total work RVUs †	1.014	1.004–1.024
Elective surgery	0.505	0.334–0.762
Open adrenalectomy	1.464	1.051–2.040
<i>Post-operative Variables</i>		
Return to Operating Room	3.265	1.329–8.017
Wound complication	6.635	3.754–11.727
Systemic infectious complication	6.455	3.891–10.711
Renal failure or insufficiency	7.104	2.625–19.226
Venous thrombotic event	11.252	5.612–22.559
Discharge to home	0.401	0.219–0.734

* ASA - American Society of Anesthesiologists;

† RVUs relative value units