Published in final edited form as:

Am J Surg. 2014 October ; 208(4): 619–625. doi:10.1016/j.amjsurg.2014.06.002.

Influence of Adrenal Pathology on Perioperative Outcomes: A Multi-Institutional Analysis

CM Kiernan¹, MC Shinall Jr¹, W Mendez², MF Peters³, JT Broome¹, and CC Solorzano¹

¹Division of Surgical Oncology/Endocrine Surgery, Vanderbilt University, Nashville, TN

²Division of Endocrine Surgery, University of Puerto Rico, San Juan, PR

³Department of Anesthesiology, Vanderbilt University, Nashville, TN

Abstract

Background—Endoscopic or open adrenalectomies are performed for variable pathologies. We investigated if adrenal pathology affects perioperative outcomes independent of operative approach.

Methods—A multi-institutional retrospective review of 345 adrenalectomies was performed. A multivariate analysis was utilized.

Results—Pathology groups included: benign non-pheochromocytoma tumors (50.4%), pheochromocytomas (41%), adrenocortical carcinomas (5.2%), and metastatic tumors (3.4%). Controlling for age, BMI, tumor size, procedure type and pathology, pheochromocytomas exhibited greater blood-loss (92mL more, $p=0.007$) and operative-times (33min more, $p<0.001$) than benign tumors. Mets demonstrated longer operative-times (53min more, $p=0.013$). Open adrenalectomy was associated with greater blood loss (396mL more, $p=0.001$), transfusion requirement ($p=0.021$), operative-times (79min more, $p<0.001$), hospital stay (6.6days more, $p<0.001$) and complications ($p<0.001$) when compared to endoscopic adrenalectomy.

Conclusions—The type of adrenal pathology appears to influence blood loss and operative time but not complications in patients undergoing adrenalectomy. Open adrenalectomy remains a major driver of adverse perioperative outcomes.

Introduction

With the improvement and frequency of imaging methods, an increasing number of adrenal lesions of all types are being detected and resected. The number of adrenalectomy procedures performed in the United States from 1998 to 2006 increased significantly from 3,241 to 5,232.¹ Since Gagner's report on the first endoscopic adrenalectomy,² several single institution retrospective studies^{3–7} and large registry database studies^{1, 8} have compared surgical outcomes according to whether the procedure was performed open or endoscopic. However, very few have compared outcomes according to adrenal pathology.

Colleen M Kiernan MD, 1161 21st Ave, CCC-4312 MCN, Nashville, TN 37232, colleen.m.kiernan@vanderbilt.edu, Phone: 815.603.5228, Fax: 615.322.0689

There are no financial disclosures.

Today, adrenalectomy remains the definitive therapy for a variety of adrenal pathologies, and endoscopic adrenalectomy (EA) has become the preferred operative approach for most. The benefits of EA when compared to open adrenalectomy (OA) include: decreased operative times, blood loss, duration of hospital stay and complications.³⁻⁷ However, some studies suggest that certain pathologies (i.e. pheochromocytoma and adrenocortical carcinoma) are more likely to have adverse operative outcomes regardless of operative approach.⁹⁻¹¹ A retrospective review of the Nationwide Inpatient Sample that included 40,353 patients who underwent adrenalectomy over an eight-year period (1998 to 2006), showed that patients with benign adrenal pathology (adrenal based hypercortisolism, hyperaldosteronism, pheochromocytoma, adrenogenital disorders and benign adenomas) were more likely to experience major complications when compared to malignant pathology (primary and metastatic).¹ Despite these results, to our knowledge there has not been a more comprehensive study of the influence of adrenal pathology on operative blood loss, transfusion requirement, procedure time, duration of hospital stay and postoperative complications. We therefore sought to determine the effect of adrenal pathology on intraoperative and postoperative outcomes while controlling for operative approach.

Methods

After obtaining institutional review board approval, a multi-institutional retrospective review of the medical records of 345 patients undergoing adrenalectomy between 2002 and 2013 was performed. The participating institutions included: The University of Miami (2007–2009), The University of Puerto Rico (2007–2012) and Vanderbilt University (2002–2013). Demographic data recorded included gender, age, race, body mass index (BMI), and presence of a familial syndrome. Familial syndromes included multiple endocrine neoplasia type 2 (MEN2), von Hippel-Lindau syndrome (VHL) and neurofibromatosis type one (NF-1). Tumor size and functional status were recorded. A tumor was considered to be functional if it produced a clinical syndrome and/or released excess aldosterone, cortisol, or catecholamines.

Operative and postoperative data recorded included operative approach, operative time (skin incision to closure), estimated blood loss (EBL), transfusion requirement, length of stay (LOS) and complications. Procedure type was defined as either endoscopic adrenalectomy (EA) or open adrenalectomy (OA). EA (n=274) included the anterior transperitoneal laparoscopic (n=188), posterior retroperitoneoscopic (n=80) and endoscopic converted to open approach (n=6).

Final pathology was grouped into benign non-pheochromocytoma tumors (BT), pheochromocytomas (pheos), adrenocortical carcinoma (ACC) and metastatic tumors (mets). Benign non-pheochromocytoma tumors (BT) included adenomas (n=149), ganglioneuromas (n=12), hyperplasia (n=6), myelolipomas (n=4) and cysts (n=3).

Statistical analysis was performed using STATA version 13.0.¹² Patient demographics, tumor characteristics, procedure type and perioperative variables were compared using chi-squared, fisher's exact, ANOVA, Kruskal-Wallis and Wilcoxon rank-sum tests. Intraoperative and perioperative outcome variables were analyzed using multivariate linear

regression and logistic regression controlling for age, BMI, tumor size, procedure type and pathology. Statistical significance was defined as a p-value of <0.05. Missing data was excluded from the analysis.

Results

Demographics and perioperative data are presented in Table 1. Overall the median patient age was 52 years, 60% were women, 85% were white and 7% had a familial syndrome. The majority of tumors were functional (75%); Forty tumors (12%) secreted cortisol, 75 (22%) aldosterone and 145 (42%) catecholamines.

On unadjusted analysis and according to adrenal pathology (Table 2), there were no significant differences in gender or race. Patients with mets were significantly older than patients with other pathologies (63 years, $p=0.04$). Patients with pheos had a significantly lower BMI when compared to patients with BT (27 vs. 30 kg/m², $p<0.001$). Pheos were larger (4.0 vs. 2.5 cm, $p<0.001$), more likely to be removed using an open approach (29% vs. 7%, $p<0.001$), had greater blood loss (100 vs. 30 ml, $p<0.001$) and a longer procedure time (150 vs. 110 min, $p<0.001$) when compared to BT. ACC tumors were larger when compared to all other pathologies (8.8 cm vs. others, $p<0.001$) and open adrenalectomy was the preferred surgical approach (83% vs. others, $p<0.001$). Mets were larger (4.6 vs. 2.5 cm, $p=0.02$), were more likely to be removed with OA (25% vs. 7% $p=0.017$) and were associated with longer procedure times (143 vs. 110 min, $p<0.001$) when compared to BT. Other significant findings in the univariate analysis were no longer significant in the multivariate analysis discussed below.

On multivariate analysis (Table 3) while controlling for age, BMI, tumor size, procedure and pathology type, a 1-point increase in BMI was associated with a 1.96 minute increase in procedure time (CI: 0.88–3.04, $p<0.001$) (not shown). When considering the different adrenal pathologies, there were no significant differences in the transfusion requirement, LOS or complication rates. Pheos and mets were associated with longer procedure times (33.2 and 53.7 min longer, respectively) when compared to BT. Pheos were associated with an increased EBL when compared to BT. Open adrenalectomy was associated with increased EBL (on average 396 mL more), increased transfusion requirement (OR 9.0), prolonged procedure time (on average 79.3 min longer), increased LOS (on average 6.6 days longer) and increased complications (OR 4.37) when compared to EA.

Overall, there were 35 patients (10%) with complications. Nine patients had more than one complication each. There was no significant difference in the number of complications according to adrenal pathology. OA was associated with an increased percentage of complications 20% (14/71) when compared to EA 8% (21/274) ($p=0.003$). Complications included: intraoperative injury to surrounding organs/structures ($n=10$), anoxic brain injury ($n=1$), respiratory failure requiring re-intubation ($n=5$), pneumonia ($n=4$), postoperative bleeding requiring operative intervention ($n=1$), anemia requiring blood transfusion ($n=2$), urinary tract infection ($n=3$), acute kidney injury ($n=4$), deep vein thrombosis/pulmonary embolus ($n=2$), ileus resulting in hospital stay equal or greater to 5 days ($n=4$), fascial dehiscence requiring operative intervention ($n=1$), hernia ($n=2$), abscess requiring

percutaneous drainage (n=3), and popliteal artery occlusion (n=1). Intraoperative injuries included: kidney laceration not requiring nephrectomy (n=3), splenic injury requiring splenectomy (n=2), injury to inferior vena cava requiring repair (n=2), small bowel injury (n=2), and colon injury (n=1). There was one mortality within 30 days of adrenalectomy. This death occurred at home three weeks postoperatively and was presumed to be secondary to arrhythmia in a patient with pre-existing cardiac disease.

Discussion

This study demonstrates that regardless of tumor size and operative approach, certain types of adrenal pathology influence intraoperative blood loss and operative time, but have no significant effect on transfusion requirement, length of hospital stay and complications. However, for all adrenal pathologies analyzed, the major driver of adverse perioperative outcomes remains the open approach to adrenalectomy.

Our data show that patients with pheos had a lower BMI when compared to patients with BT. The higher BMI observed in the BT group, can be partially explained by the inclusion of cortisol producing tumors in this group. Obesity is a known side effect of hypercortisolism¹³ and in this study patients with adrenal based hypercortisolism had a significantly higher BMI when compared to all other pathologies (data not shown).

Pheochromocytoma tumors were significantly larger than those in the BT group (4 vs. 2.5 cm). This observation is consistent with a prior report by Gagner and colleagues who reviewed 100 patients undergoing adrenalectomy. The average size of pheos in their series was 6.3 cm compared to 3.9 cm in non-pheochromocytomas.⁵ Kim et al. compared the size of pheos to that of aldosterone producing tumors; the average size of pheos was 4.9 cm compared to 2.7 cm, respectively.¹⁰ The larger tumors observed at presentation in the pheo group may illustrate the difficulties in their diagnosis and maybe their predilection for a faster growth rate.¹⁴ Overall, in this report, the majority of pheos were removed using the endoscopic approach; however, when compared to BT, pheos were more likely to be removed using an open approach. Several studies have shown that endoscopic adrenalectomy is safe and effective for larger pheos (> 6cm)^{15–17} yet larger pheos pose unique technical challenges during endoscopic surgery. Larger tumors result in a smaller operative space and therefore make mobilization more difficult. In addition, the increased vascularity and friability displayed by these tumors can make the operation quite challenging. Our results support prior observations and indicate that adrenalectomy for pheochromocytomas, even when controlled for operative approach, is associated with increased blood loss, longer procedure times and more open procedures when compared to BT.¹⁰

In this series, ACC tumors were larger when compared to all other pathologies. This observation supports prior findings that larger adrenal tumors are more likely to be adrenocortical carcinoma.¹⁸ Surprisingly, even though ACC tumors were treated with OA 83% of the time, on adjusted analysis, this pathology was not associated with increased intraoperative blood loss, operative time or complications when compared to other tumor types. Open adrenalectomy was the preferred approach to ACC due to our philosophy that

OA confers an oncologic advantage.^{11, 19, 20} Adjusting for T stage, Cooper et al. demonstrated a significant increase in overall and disease free survival as well as peritoneal recurrence free survival when OA was performed for ACC compared to EA.⁹ However, small retrospective case studies with incomplete oncologic follow-up have shown that EA is safe for removal of ACC.^{21, 22} Thus, debate still remains as to the applicability of EA for known ACC.

Patients with metastatic adrenal lesions were older, had lower BMI, presented with larger tumors and were more likely to undergo OA when compared to BT. These findings are likely due to the fact that cancer typically presents at an older age, results in treatment or disease related weight loss and grows faster than benign tumors. Strong and colleagues showed that EA is safe and equivalent to OA in terms of margin status, local recurrence, disease-free interval and overall survival for patients with mets; however, there was a trend in their series for tumors >4.5 cm to be removed using OA.²³ On adjusted analysis, resection of mets was associated with longer procedure times. Porpiglia and colleagues showed that the sclerotic reaction of the peri-adrenal tissues caused by the malignant lesion, in addition to the need for accurate dissection to respect oncologic principles leads to increased operative times.²⁴

When controlling for several factors, including operative approach, adrenal pathology was not associated with an increased incidence of complications. The current results differ from a retrospective review of the Nationwide Inpatient Sample showing that patients with benign pathology (adrenal based hypercortisolism, hyperaldosteronism, pheochromocytoma, adrenogenital disorders and benign adenomas) were more likely to experience major complications when compared to those with malignant pathology (primary and metastatic). They attributed their findings to the inclusion of “functional tumors” in the benign pathology group and the hemodynamic fluctuations associated with these tumors.¹ While it is not explicitly discussed in their paper, this implies that pheochromocytomas were the main culprit of postoperative morbidity associated with benign tumors. However, in our study and in a study by Kim et al. pheochromocytomas were not associated with increased complications when compared to benign pathology. The overall complication rate observed in this study was 10%. Elfenbein and colleagues reviewed the records of 3100 patients who underwent adrenalectomy and were included in the American College of Surgeons-National Surgery Quality Improvement Project (NSQIP); the overall 30 day morbidity rate was 9%.²⁵ Similarly, in a review of the Veterans Affairs-NSQIP data of 769 patients who underwent adrenalectomy, the overall 30-day morbidity was 10%.⁸

While the primary focus of this study was outcomes by adrenal pathology, as a secondary aim we analyzed outcomes by procedure type. Our results were consistent with previously published studies^{3-5, 7} showing that OA is associated with increased blood loss, transfusion requirement, procedure times, hospital stay and a greater number of complications when compared to EA. Despite these outcomes, we believe that OA remains a necessary procedure for certain tumors such as ACC, where it provides an oncologic advantage. OA is also necessary when EA is technically not possible.

This study has several limitations. First, any retrospective study is limited by the quality and inconsistency of data in the medical record. Additionally despite the benefit of increasing sample size, a multi-institutional study is limited by variability in data collection and access to data for clarification. This study was unable to control for co-morbid conditions since this information was not complete. We were unable to analyze each individual benign pathology type in our multivariate analysis. This resulted in a group of unrelated adrenal tumors that we called BT, while clinical experience and previously published data suggest these tumors do not behave differently, future studies with a larger number of patients are needed to confirm if these benign pathologies are in fact associated with different outcomes.

In conclusion, adrenal pathology influences intraoperative blood loss and procedure time during adrenalectomy but does not affect transfusion requirement, LOS or complication rates. Patients can be counseled that pheos and metastases will require longer procedure times and pheos will have greater intraoperative blood loss although this blood loss does not affect transfusion rates or clinical outcomes. Open adrenalectomy is associated with a significant increase in blood loss, transfusion requirement, procedure times, hospital stay and complications. When determined safe and oncologically appropriate, endoscopic procedures should be the preferred approach to adrenalectomy.

References

1. Murphy MM, Witkowski ER, Ng SC, McDade TP, Hill JS, Larkin AC, et al. Trends in adrenalectomy: a recent national review. *Surgical endoscopy*. 2010; 24(10):2518–2526. [PubMed: 20336320]
2. Gagner M, Lacroix A, Bolte E. Laparoscopic adrenalectomy in Cushing's syndrome and pheochromocytoma. *The New England journal of medicine*. 1992; 327(14):1033. [PubMed: 1387700]
3. Bittner, JGt; Gershuni, VM.; Matthews, BD.; Moley, JF.; Brunt, LM. Risk factors affecting operative approach, conversion, and morbidity for adrenalectomy: a single-institution series of 402 patients. *Surgical endoscopy*. 2013; 27(7):2342–2350. [PubMed: 23404146]
4. Brunt LM, Doherty GM, Norton JA, Soper NJ, Quasebarth MA, Moley JF. Laparoscopic adrenalectomy compared to open adrenalectomy for benign adrenal neoplasms. *Journal of the American College of Surgeons*. 1996; 183(1):1–10. [PubMed: 8673301]
5. Gagner M, Pomp A, Heniford BT, Pharand D, Lacroix A. Laparoscopic adrenalectomy: lessons learned from 100 consecutive procedures. *Ann Surg*. 1997; 226(3):238–246. discussion 46–7. [PubMed: 9339930]
6. Imai T, Kikumori T, Ohiwa M, Mase T, Funahashi H. A case-controlled study of laparoscopic compared with open lateral adrenalectomy. *American journal of surgery*. 1999; 178(1):50–53. discussion 4. [PubMed: 10456703]
7. Smith CD, Weber CJ, Amerson JR. Laparoscopic adrenalectomy: new gold standard. *World journal of surgery*. 1999; 23(4):389–396. [PubMed: 10030863]
8. Lee J, El-Tamer M, Schiffner T, Turrentine FE, Henderson WG, Khuri S, et al. Open and laparoscopic adrenalectomy: analysis of the National Surgical Quality Improvement Program. *Journal of the American College of Surgeons*. 2008; 206(5):953–959. discussion 9–61. [PubMed: 18471733]
9. Cooper AB, Habra MA, Grubbs EG, Bednarski BK, Ying AK, Perrier ND, et al. Does laparoscopic adrenalectomy jeopardize oncologic outcomes for patients with adrenocortical carcinoma? *Surgical endoscopy*. 2013; 27(11):4026–4032. [PubMed: 23765427]
10. Kim AW, Quiros RM, Maxhimer JB, El-Ganzouri AR, Prinz RA. Outcome of laparoscopic adrenalectomy for pheochromocytomas vs aldosteronomas. *Archives of surgery (Chicago, Ill: 1960)*. 2004; 139(5):526–529. discussion 9–31.

11. Miller BS, Ammori JB, Gauger PG, Broome JT, Hammer GD, Doherty GM. Laparoscopic resection is inappropriate in patients with known or suspected adrenocortical carcinoma. *World journal of surgery*. 2010; 34(6):1380–1385. [PubMed: 20372905]
12. StataCorp. Stata Statistical Software. 13 ed. College Station, Tx: Stata Corp LP; 2013.
13. Nieman LK, Ilias I. Evaluation and treatment of Cushing's syndrome. *The American journal of medicine*. 2005; 118(12):1340–1346. [PubMed: 16378774]
14. Manger WM, Gifford RW. Pheochromocytoma. *Journal of clinical hypertension (Greenwich, Conn)*. 2002; 4(1):62–72.
15. Asari R, Koperek O, Niederle B. Endoscopic adrenalectomy in large adrenal tumors. *Surgery*. 2012; 152(1):41–49. [PubMed: 22483579]
16. Janetschek G, Finksteden G, Gasser R, Waibel UG, Peschel R, Bartsch G, et al. Laparoscopic surgery for pheochromocytoma: adrenalectomy, partial resection, excision of paragangliomas. *The Journal of urology*. 1998; 160(2):330–334. [PubMed: 9679871]
17. Wilhelm SM, Prinz RA, Barbu AM, Onders RP, Solorzano CC. Analysis of large versus small pheochromocytomas: operative approaches and patient outcomes. *Surgery*. 2006; 140(4):553–559. discussion 9–60. [PubMed: 17011902]
18. Sturgeon C, Shen WT, Clark OH, Duh QY, Kebebew E. Risk assessment in 457 adrenal cortical carcinomas: how much does tumor size predict the likelihood of malignancy? *Journal of the American College of Surgeons*. 2006; 202(3):423–430. [PubMed: 16500246]
19. Gonzalez RJ, Shapiro S, Sarlis N, Vassilopoulou-Sellin R, Perrier ND, Evans DB, et al. Laparoscopic resection of adrenal cortical carcinoma: a cautionary note. *Surgery*. 2005; 138(6):1078–1085. discussion 85–6. [PubMed: 16360394]
20. Leboulleux S, Deandreis D, Al Ghuzlan A, Auperin A, Goere D, Dromain C, et al. Adrenocortical carcinoma: is the surgical approach a risk factor of peritoneal carcinomatosis? *European journal of endocrinology / European Federation of Endocrine Societies*. 2010; 162(6):1147–1153. [PubMed: 20348273]
21. Brix D, Allolio B, Fenske W, Agha A, Dralle H, Jurowich C, et al. Laparoscopic versus open adrenalectomy for adrenocortical carcinoma: surgical and oncologic outcome in 152 patients. *European urology*. 2010; 58(4):609–615. [PubMed: 20580485]
22. Lombardi CP, Raffaelli M, De Crea C, Boniardi M, De Toma G, Marzano LA, et al. Open versus endoscopic adrenalectomy in the treatment of localized (stage I/II) adrenocortical carcinoma: results of a multiinstitutional Italian survey. *Surgery*. 2012; 152(6):1158–1164. [PubMed: 23068084]
23. Strong VE, D'Angelica M, Tang L, Prete F, Gonen M, Coit D, et al. Laparoscopic adrenalectomy for isolated adrenal metastasis. *Annals of surgical oncology*. 2007; 14(12):3392–3400. [PubMed: 17665267]
24. Porpiglia F, Fiori C, Tarabuzzi R, Giraudo G, Garrone C, Morino M, et al. Is laparoscopic adrenalectomy feasible for adrenocortical carcinoma or metastasis? *BJU international*. 2004; 94(7):1026–1029. [PubMed: 15541121]
25. Elfenbein DM, Scarborough JE, Speicher PJ, Scheri RP. Comparison of laparoscopic versus open adrenalectomy: results from American College of Surgeons-National Surgery Quality Improvement Project. *The Journal of surgical research*. 2013; 184(1):216–220. [PubMed: 23664532]

Table 1

Patient demographics and perioperative data

	Total (n=345)
Gender	
Male	139 (40%)
Female	206 (60%)
Age (years)	52 (42–62)
BMI (units)	28 (25–33)
Race *	
White	262 (85%)
Non-white	44 (15%)
Familial Syndrome*	
Yes	22 (7%)
No	306 (93%)
Functional Tumor	
Yes	260 (75%)
No	85 (25%)
Tumor Size (cm)	3.5 (2–6)
Procedure Type	
EA	274 (79%)
OA	71 (21%)
Conversions	6 (1.7%)
Procedure Time (min)	130 (91–180)
EBL (mL)	50 (20–170)
Transfusion*	
Yes	20 (6%)
No	317 (94%)
LOS (days)	2 (1–3)
Complications	
Yes	35 (10%)
No	310 (90%)

Median values with interquartile range (IQR)

BMI, body mass index; cm, centimeters; min, minutes; mL, milliliters; LOS, length of stay; EA, endoscopic adrenalectomy; OA, open adrenalectomy

* Denotes missing data

Table 2

Patient demographics and perioperative data by tumor pathology

	BT (n=174)	Pho (n=141)	ACC (n=18)	Mets (n=12)	p-value
Gender					
Male	60 (34%)	64 (45%)	8 (44%)	7 (58%)	0.126
Female	114 (66%)	77 (55%)	10 (56%)	5 (42%)	
Age (years)	51 (42–62)	52 (40–61)	46 (41–59)	63 (55–70)	0.040
BMI (kg/m ²)	30 (26–36)	27 (24–30)	28 (23–32)	26 (25–31)	<0.001
Race *					0.45
White	143 (83%)	93 (87%)	15 (88%)	11 (100%)	
Non-White	28 (16%)	14 (13%)	2 (12%)	0 (0%)	
Tumor Size (cm)	2.5 (1.5–4.4)	4.0 (2.9–6.3)	8.8 (5.4–10.5)	4.6 (2.8–5.5)	<0.001
Functional Tumor					<0.001
Yes	121 (70%)	138 (98%)	1 (6%)	0 (0%)	
No	53 (30%)	3 (2%)	17 (94%)	12 (100%)	
Procedure Type					<0.001
EA	162 (93%)	100 (71%)	3 (17%)	9 (75%)	
OA	12 (7%)	41 (29%)	15 (83%)	3 (25%)	
Procedure time (min)	110 (85–150)	150 (105–219)	180 (156–253)	143 (108–170)	<0.001
EBL (mL)	30 (10–100)	100 (25–250)	210 (150–500)	125 (40–213)	<0.001
Transfusion *					<0.001
Yes	2 (1%)	16 (11%)	3 (14%)	1 (8%)	
No	167 (99%)	125 (89%)	14 (82%)	11 (92%)	
LOS (days)	2 (1–2)	2 (2–4)	5 (3–5)	2 (1–4)	<0.001
Complications					0.203

	BT (n=174)	Pheo (n=141)	ACC (n=18)	Mets (n=12)	p-value
Yes	14 (9%)	15 (20%)	3 (17%)	3 (25%)	
No	160 (91%)	126 (90%)	15 (83%)	9 (75%)	

Median values with interquartile range (IQR)

BT, benign non-pheochromocytoma tumors; Pheo, pheochromocytoma; ACC adrenocortical carcinoma; Mets, metastases; BMI, body mass index; cm, centimeters; EA, endoscopic adrenalectomy; OA, open adrenalectomy; min, minutes; mL, milliliters; EBL, estimated blood loss; LOS, length of stay

* denotes missing data; missing data was excluded from the analysis

Table 3

Outcome variables: Multivariate analysis

EBL	<i>Coefficient</i>	<i>CI</i>	<i>p value</i>
Tumor Size	5.16	−23–33	0.718
Procedure type			<0.001
EA	reference		
OA	396	173–619	0.001
Pathology			0.023
BT	reference		
Pheo	92	25–159	0.007
ACC	681	−674–2037	0.323
Mets	183	−85–451	0.180
Transfusion	<i>OR</i>	<i>CI</i>	<i>p value</i>
Tumor Size	1.05	0.90–1.24	0.459
Procedure type			0.021
EA	reference		
OA	9.03	1.39–58.69	0.021
Pathology			0.515
BT	reference		
Pheo	2.61	0.36–18.82	0.340
ACC	2.14	0.21–21.14	0.515
Mets	6.32	0.54–73.44	0.140
Procedure Time	<i>Coefficient</i>	<i>CI</i>	<i>p value</i>
Tumor Size	1.28	−1.93–4.51	0.433
Procedure type			<0.001
EA	reference		
OA	79.3	53.7–104.8	<0.001
Pathology			<0.001
BT	reference		
Pheo	33.2	15.7–50.7	<0.001
ACC	21.2	−17.2–59.6	0.278
Mets	53.7	11.2–96.4	0.013
LOS	<i>Coefficient</i>	<i>CI</i>	<i>p value</i>
Tumor Size	0.02	−0.06–0.11	0.588
Procedure type			0.003

EBL	<i>Coefficient</i>	<i>CI</i>	<i>p value</i>
EA	reference		
OA	6.6	2.3–10.9	0.003
Pathology			0.623
BT	reference		
Pheo	−0.6	−2.3–1.1	0.484
ACC	0.46	−4.5–5.4	0.854
Mets	4.9	−6.9–16.8	0.417
Complications	<i>OR</i>	<i>CI</i>	<i>p value</i>
Tumor Size	0.88	0.78–1.00	0.050
Procedure type			0.001
EA	reference		
OA	4.37	1.77–10.77	0.001
Pathology			0.148
BT	reference		
Pheo	0.77	0.29–2.07	0.975
ACC	1.48	0.29–7.37	0.518
Mets	4.09	1.01–16.46	0.043

EBL, estimated blood loss; CI, confidence interval; EA, endoscopic adrenalectomy; OA, open adrenalectomy; BT, benign non-pheochromocytoma tumors; Pheo, pheochromocytoma; ACC adrenocortical carcinoma; Mets, metastases; LOS, length of stay; OR, odds ratio

Controlling for Age, BMI, tumor size, procedure type, pathology